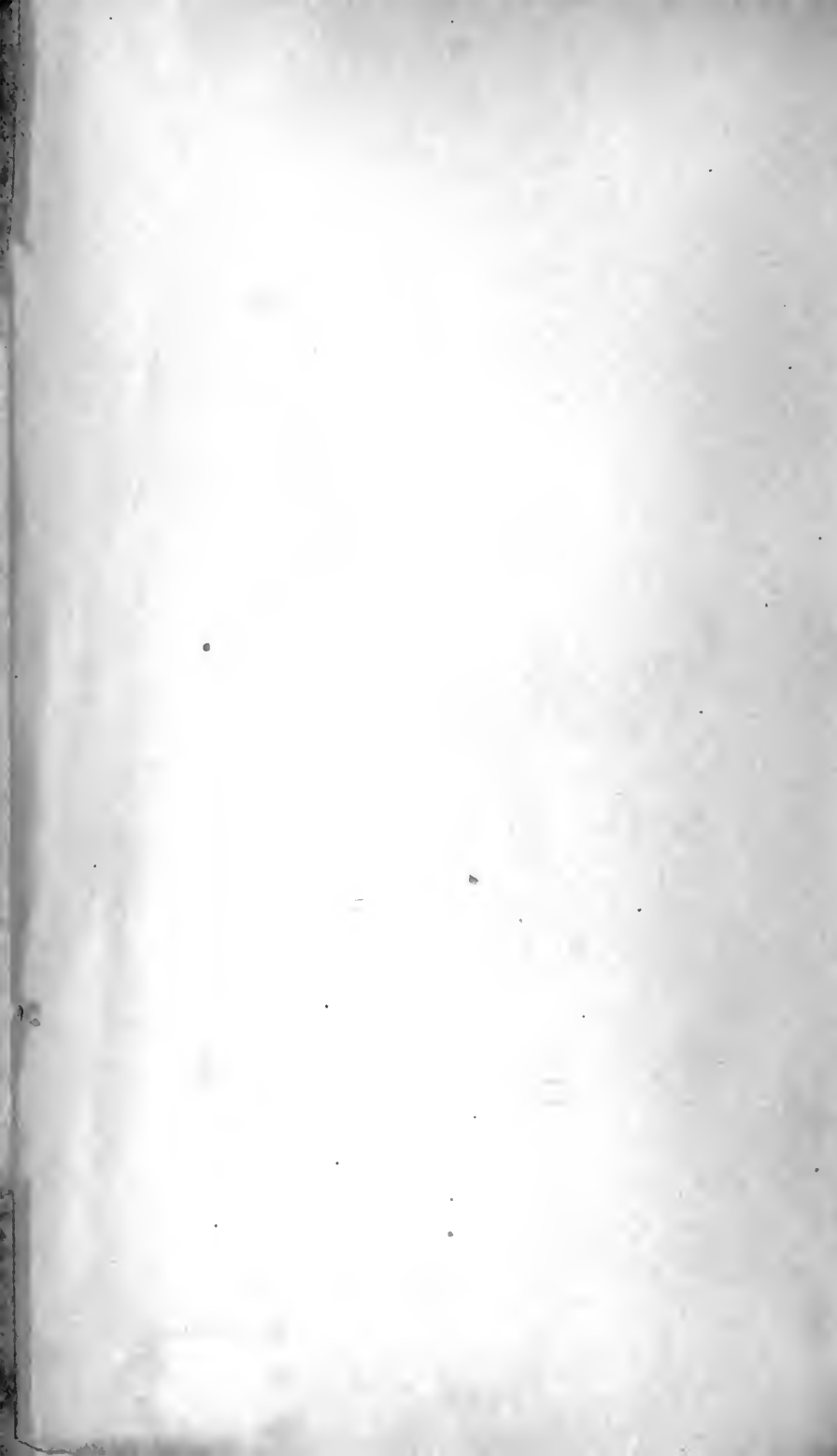
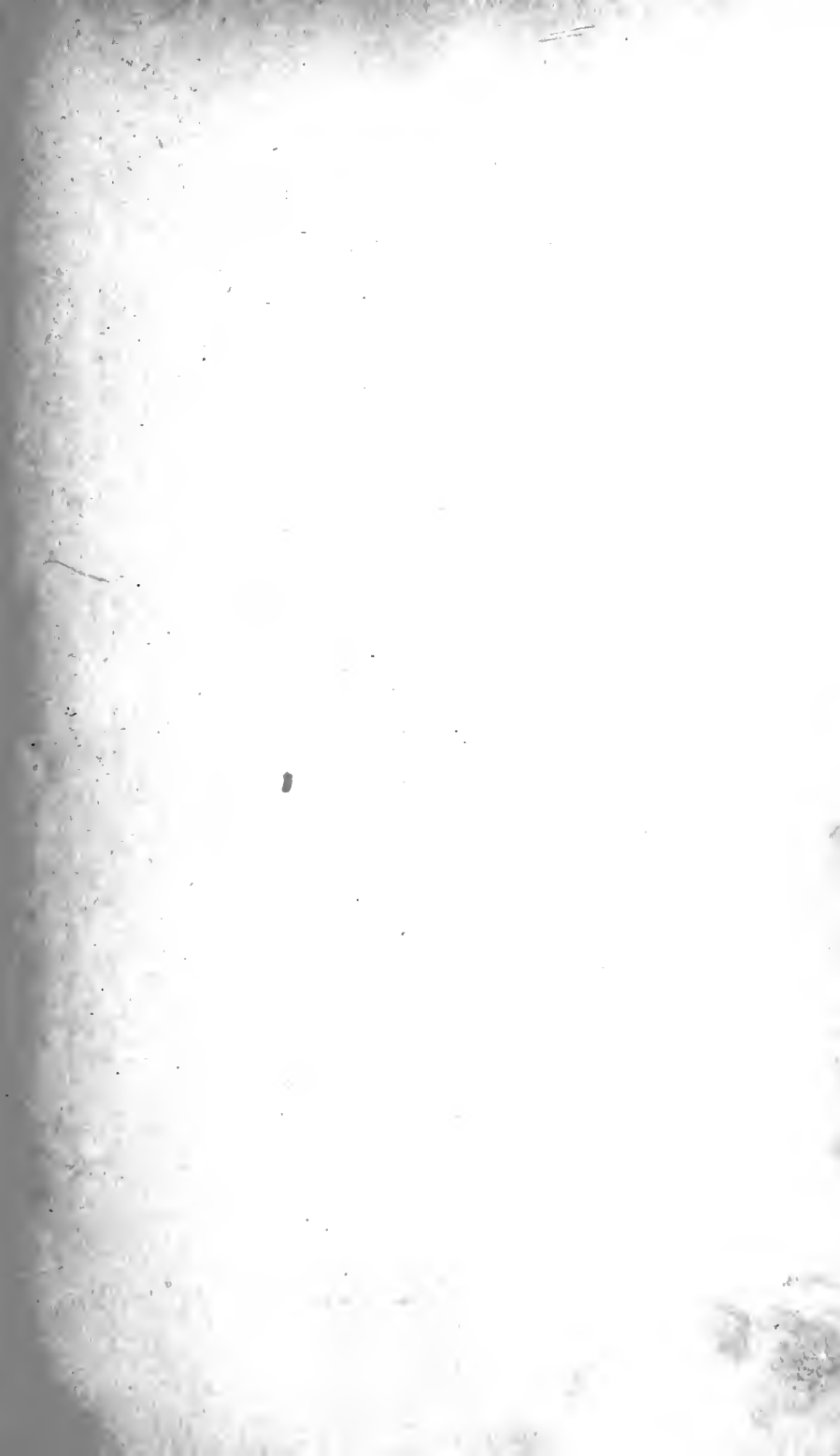
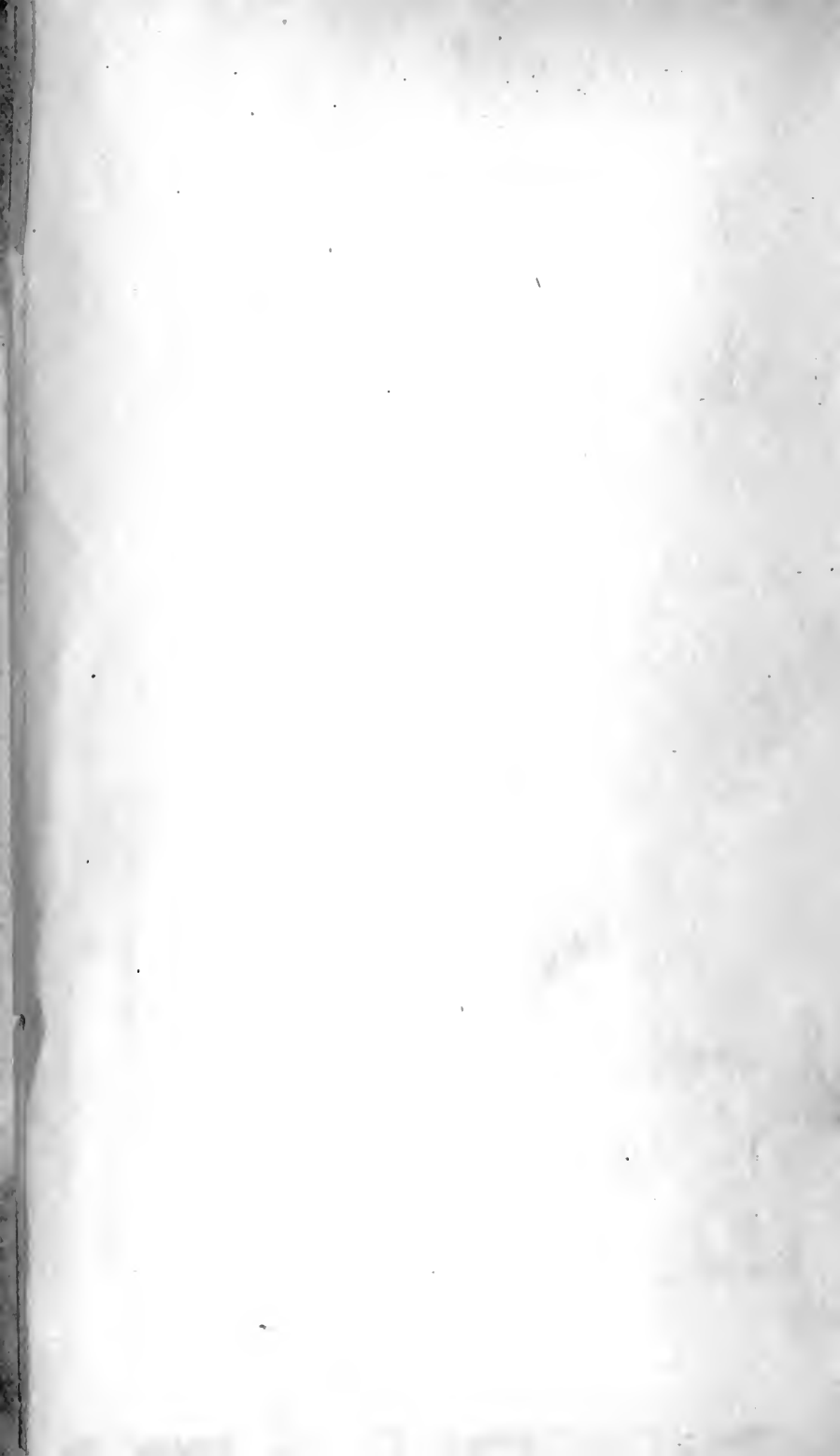


THE ROYAL CANADIAN MOUNTED POLICE







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THE
JOURNAL

OF THE
FRANKLIN INSTITUTE

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SCIENCE AND THE MECHANIC ARTS.

EDITED BY

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FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LXVII.]

JANUARY, 1874.

No. 1.

EDITORIAL.

ITEMS AND NOVELTIES.

The Centennial Exposition.—The movement in aid of this great national project is making steady progress. The active co-operation of a number of the States has at length been obtained, or pledged, and the outlook for the early undertaking of active operations in its behalf is most favorable.

The plan of the buildings in which the Exposition is to be held has already been decided upon, the successful architect being Mr. Vaux, of New York city. The accompanying plate represents a ground plan of these buildings, which it is proposed to erect at the earliest period, upon the site, in Fairmount Park, donated by the city of Philadelphia to the U. S. Centennial Commission for the purposes of the Exposition.*

This plan gives an idea of the relative position of the several buildings, and, to those familiar with the location, their relation to well-known portions of the Park. The following table of references gives the designation and functions of the several parts of the plan, viz.:

A. The Machinery Hall.

B. The Agricultural Hall.

* We are indebted for the plate to the courtesy of the Editors of the Jour. of the Exposition and Evening Bulletin, Philadelphia.

C. The Conservatory.

E. Centennial Avenue.

F. The Terrace.

H. George's Hill.

M. The Art Gallery.

N. Covered Way between the Buildings.

K. Belmont Reservoir.

P. Main Exposition Building.

The grand pavillion, or main exposition building (marked P), according to present design, will have a length of 2,075 feet, and a width at the centre and ends of 1,000 feet. The length of Agricultural Hall will be 1,420 feet, and of Machinery Hall 2,275 feet.

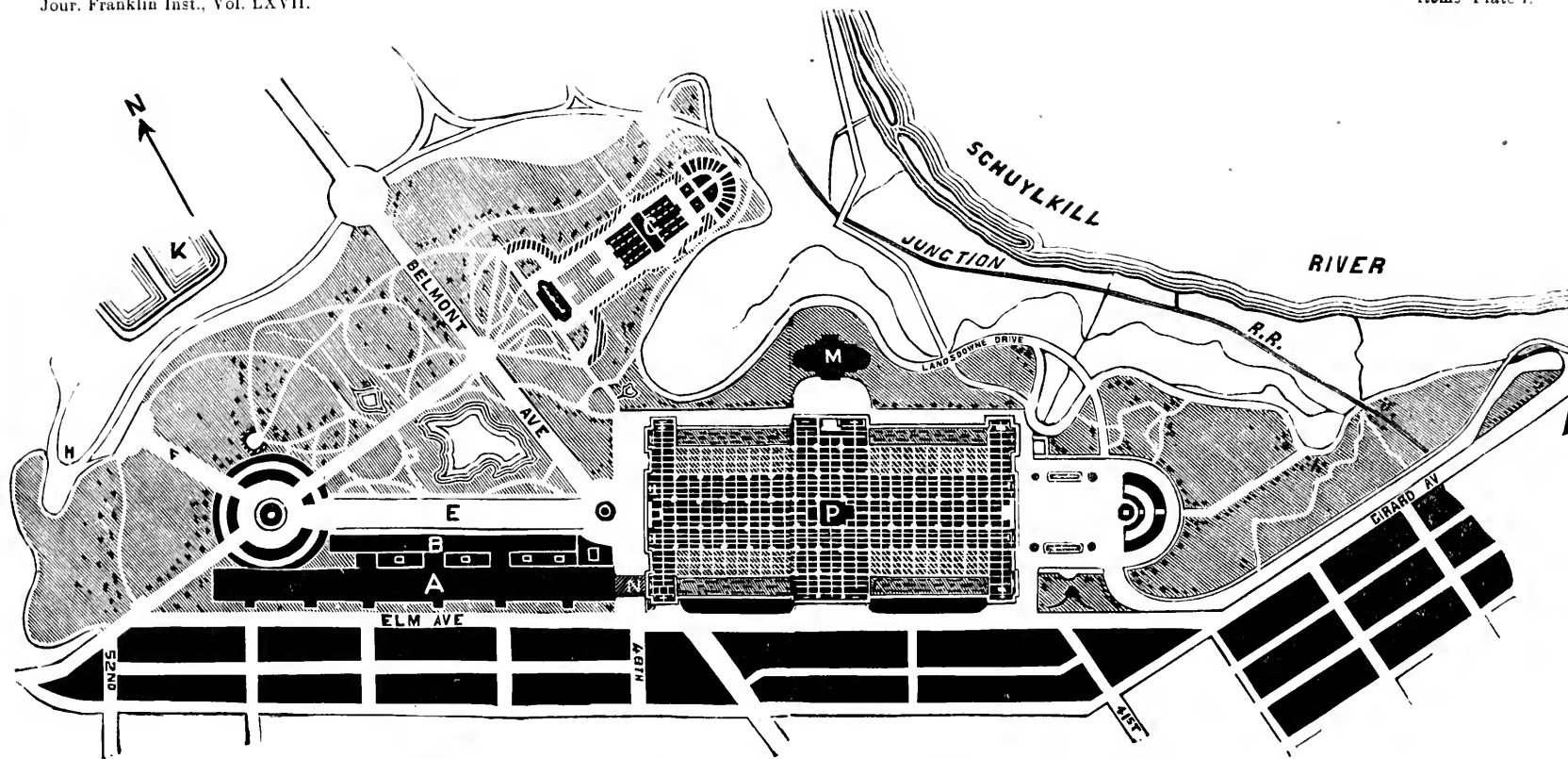
The area of ground appropriated in the Park for the purposes of the Exposition is 450 acres. Of this space, the Grand Pavillion covers $35\frac{1}{2}$ acres, with the capacity of considerable extension if found necessary, or expedient. The Machinery Hall will cover $9\frac{1}{2}$ acres, and the Agricultural Hall $4\frac{1}{2}$ acres.

It will be observed that Machinery Hall is to be located directly upon Elm Avenue, within a very short distance of the Pennsylvania Railroad tracks, so that no difficulty will be found in making a siding upon which heavy castings, etc., can be run directly into the Hall.

The following figures represent the areas of former expositions, and will serve as a comparison with that appropriated for the coming event.

The space included for the purposes of the Exposition was, at—	Sq. Yards.
London (Hyde Park), 1851,	88,934
Paris (Champs Elysées), 1855,	112,450
London (Brompton), 1862,	202,920
Paris (Champs de Mars), 1867,	481,500
Vienna (Prater), 1873,	2,530,400
Philadelphia (Fairmount Park), 1876,	3,070,000

In continuation of the same subject, it may be interesting to add, in conclusion, that Prof. W. P. Blake, of Connecticut, a member of the United States Centennial Commission, has prepared a somewhat voluminous report of his mission to the Vienna Exposition, he having been assigned this duty by the Centennial Executive Committee. He refers with great satisfaction to the general sentiment abroad in reference to the American Centennial Exposition. In reference to what foreigners expect, Prof. Blake says: A very intelligent interest



GROUND PLAN OF BUILDINGS FOR THE CENTENNIAL EXPOSITION, 1876.

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was manifested generally by the exhibitors at Vienna, and there were inquiries for the regulations in detail of our exhibition. It is here my duty to state plainly that, notwithstanding the very favorable disposition shown, not only by Austro-Hungary, but by the German empire, Belgium and other countries, they will not participate with us unless they are fully satisfied with our plans and regulations. The exhibitors are now so habituated to great international exhibitions that they are intelligent critics of their organization and regulations. They have had disagreeable experience in some respects, and they will not subject themselves to like difficulties. They, therefore, look with anxiety to the tenor of our regulations, and it behooves us to exercise extreme caution in regard to them.

I herewith submit some of the points upon which anxiety has been manifested, and suggestions have been made by some of the foreign commissions and exhibitors :

First. Protection of their property and protection of the interests of exhibitors. To this end the organization of a responsible body to act as agent of foreign exhibitors to receive, place, describe, guard and to dispose of or return articles sent, and further to give information concerning them to jurors or others.

Second. A well-devised system of awards, a judicious selection of jurors, and effective organization of the jury.

Third. Facilities for transportation and protection from needless expenses of moving, unpacking, placing and removing goods.

Fourth. Favorable and simple customs regulations.

Fifth. Permission to trade under proper restrictions.

Sixth. Facilities for advertising.

Seventh. Early publication of a good catalogue assured.

Eighth. Provision for descriptive reports and publication of the results of the exhibition.

A Remarkable Experiment in Punching Cold Iron.—At the meeting of the Franklin Institute, held in December, 1873, two cold-punched hexagon nuts were exhibited by Messrs. Hoopes & Townsend, bolt, nut and washer makers, of this city. These specimens are worthy of attention from the fact that one of them had a hole one quarter of an inch in diameter and one inch deep; the other was perforated with a hole half an inch in diameter and one and a half inch deep.

These specimens are remarkable, when we take into consideration

the oft-made statement "that the maximum thickness of iron that can be punched cold is about the diameter of the punch," as the depth of the smaller nut is four diameters of the punch, and that of the larger one three diameters of the punch.

In conversation with Mr. Barton Hoopes, who has conducted these experiments, I learn that he has since succeeded in punching a half-inch hole through inch and three-quarters thickness of wrought iron; the punching which came out of the hole I have examined, and it differs in no respect from ordinary punchings, but it has been compressed to seven-eighths of an inch in length; that is, the punching shows an irregular cylinder half inch in diameter and seven-eighths inch long: the metal forming the punching is not condensed into a smooth cylinder, but shows the usual roughness common to all punchings, while the punched holes are very smooth. The punch and die-hole are the same size, and there has evidently been a side flow of the cold iron upon the entrance of the punch. The operation may, in a measure, be considered a piercing one up to a certain depth, and finally a punching out of the residuum after it has attained that depth.

In punching the quarter-inch hole through one-inch iron, the punching showed a very smooth surface, and was only three-eighths of an inch long, seemingly very much compressed.

I have examined the punches used in this curious experiment, and find that they differ in no respect from ordinary punches. They are made of good steel, and hardened in some peculiar manner unknown to me.

Bars of iron one inch square, punched with a quarter inch punch, show a sensible widening under the action of the punch, and a bar of inch and three-quarters square iron, punched with a half-inch punch, is swelled sideways to one inch and thirteen-sixteenths, showing conclusively that some of the iron has been forced sideways.

The machines used in driving the punch through this great thickness are said to be of great strength and accuracy of construction.

COLEMAN SELLERS.

South Street Bridge.—The following information from official source may interest our readers:

This structure is approaching completion. The caps that carry the superstructure are now being put in place upon the pneumatic cylinders, and these, when finished, which will be in a few days, will en-

able the work of the erection of the iron superstructure to go on. The iron work is being rapidly executed in the different shops, and it is confidently expected that this beautiful bridge will be ready for crossing early in the spring of 1874.

The superstructure, which will be entirely of wrought iron, will be characterized by several new features. The diagonals, both main and counters, are flat bars, generally 10 inches in width, with a varying thickness proportional to the strain. The object in this is to avoid the frail cobweb appearance of a like structure with diagonals of round or square forms. All the columns or posts are of the Reeves' Patent, the neck at the top chord finished with a delicate Corinthian-leaved capital; the columns and cross girders are braced with strong wrought iron fret arches. Three of these arches spring from each post, the effect of them enclosing, as it will appear from the inside, the rich Corinthian capitals of the post will be that of a long vista, and when lighted at night cannot fail to be beautiful. At all events, Mr. Murphy, the designer and builder, has made a successful attempt at gaining a new style in bridge architecture. When the Fairmount and Girard Avenue bridges are completed, Philadelphia can boast that she has at least four grand bridges, including the Chestnut St., and each bridge in a different style of architecture, and each bridge by a different Philadelphia Civil Engineer.

The Boiler Tests at Sandy Hook.—The U. S. Commission appointed to conduct a series of experimental trials with steam boilers, with the view of determining the truth or fallacy of the numerous theories of steam boiler explosions, commenced its work at Sandy Hook on the 7th of November.

The constitution of the Commission, and an outline of the work it has prepared, have already been published in the Journal.

The boilers experimented upon were two in number: one of them a small, upright, tubular boiler, and the other a large low pressure boiler, such as is in general use on steamers in New York harbor.

The aim of the experiment with the first-named boiler was to test the theory that, with low water in the boiler, the plates may become heated sufficiently to materially diminish their power of resisting strain.

During the experiment, the spectators occupied a bomb-proof casemate, some hundreds of feet from the boiler. The result was the collapsing of a tube at a pressure of 54 pounds. A pyrometer at-

tached to the lower part of the boiler indicated that the steam in the upper part of the boiler was highly superheated at the moment of explosion, and the opinion prevailed that the experiment proved the truth of the theory.

The low pressure boiler was heated to a steam pressure of 70 lbs., at which point it ruptured a seam without doing further damage. The rupture occurred in a soft patch on the upper side of the shell, and was about 18 inches long.

It was shown by the gauges that, even after the rupture occurred, the pressure continued to increase, and the rupture did not extend. It was therefore concluded that overpressure of steam will rupture a boiler with a weak spot, while if it be uniformly strong in all its parts, it will, in all probability, explode violently from this cause—a conclusion simply reiterating that announced by Col. Stephens, from experiments at the same place some two years ago, and then published in the Journal. The experiments were continued at Pittsburg, and have been postponed until the spring.

The Lost Telegraphic Cable.—From the *Scientific American* we learn that the recent attempt of the Great Eastern to lift and repair the Atlantic Cable of 1868 has failed, owing to stormy weather, and that the great ship has returned to England. The work will shortly be resumed. The fault has been located at a point not far eastward of the banks of New Foundland. The cable was successfully grappled and lifted several times. A portion of the original cable, that of 1858, was brought up during the grappling operations, and was found to be in a good state of preservation.

Iron and Steel Production in the United States.—From the recently published statistical report of the Secretary of the American Iron and Steel Association, we obtain the following information concerning this subject, which cannot fail to be read with interest.

There were produced in the United States in 1872 about 32,000 net tons of cast steel, and in 1873 there will be produced about 28,000 tons. In 1871 there were converted 45,000 net tons of Bessemer steel; in 1872, 110,500 tons; and in 1873 there will be converted 140,000 tons. About 85 per cent. of the Bessemer steel that is now converted in American works passes into rails.

The total quantity of pig metal converted in this country by the pneumatic process, in the year 1872, was 125,361 gross tons. During the first nine months of 1873, the total quantity converted was 127,384 tons.

The production of steel, in the United States, by the Siemens-Martin process aggregated only a few thousand tons in 1872. The business was confined to seven establishments. As this quality of steel cannot be so cheaply produced as Bessemer steel, it is difficult to estimate the extent to which its production will be carried in future years, but we hear of one new enterprise in its manufacture having been inaugurated this year.

Bessemer works, for the conversion of steel and the rolling of rails, are now in operation at the following places; viz: Troy, N. Y.; Johnstown, Pa.; Harrisburg, Pa.; Bethlehem, Pa.; Newburg, Ohio; Chicago, Illinois (two separate establishments); and Joliet, Illinois. The Pennsylvania steel works, at Harrisburg, are building a new plant, to be completed in 1874, which will double their present capacity. The Edgar Thompson steel works, near Pittsburg, Pa., are in course of erection, and, it is expected, will be finished in 1874.

The total capacity of the eight Bessemer steel-works now in operation is about 170,000 net tons of rails; to which add Edgar Thompson, and the new plant at the Pennsylvania steel works, and the total capacity of these works in the United States, at the close of 1874, may be placed at 224,000 net tons of rails.

Summary of Iron and Steel Production.—The following is a summary, in net tons, of the ascertained and estimated production of iron and steel in the United States, in 1872 and 1873:—

	1872.	1873.
Iron and steel rails, . . .	941,992	850,000
Other rolled and hamered iron, . . .	1,000,000	980,000
Forges and bloomeries, . . .	58,000	50,000
Cast steel,	32,000	28,000
Bessemer steel,	110,500	140,000
Siemens-Martin steel, . . .	3,000	3,500
Pig iron,	2,830,070	2,695,434

A New Indicating Apparatus.—(WALTER HART, Philada).—

This apparatus, for practical and experimental use as an attachment to boilers, stills, digesters and vacuum pans, is designed to be used by refiners, distillers and manufacturers of sugar, petroleum, spirits and other substances.

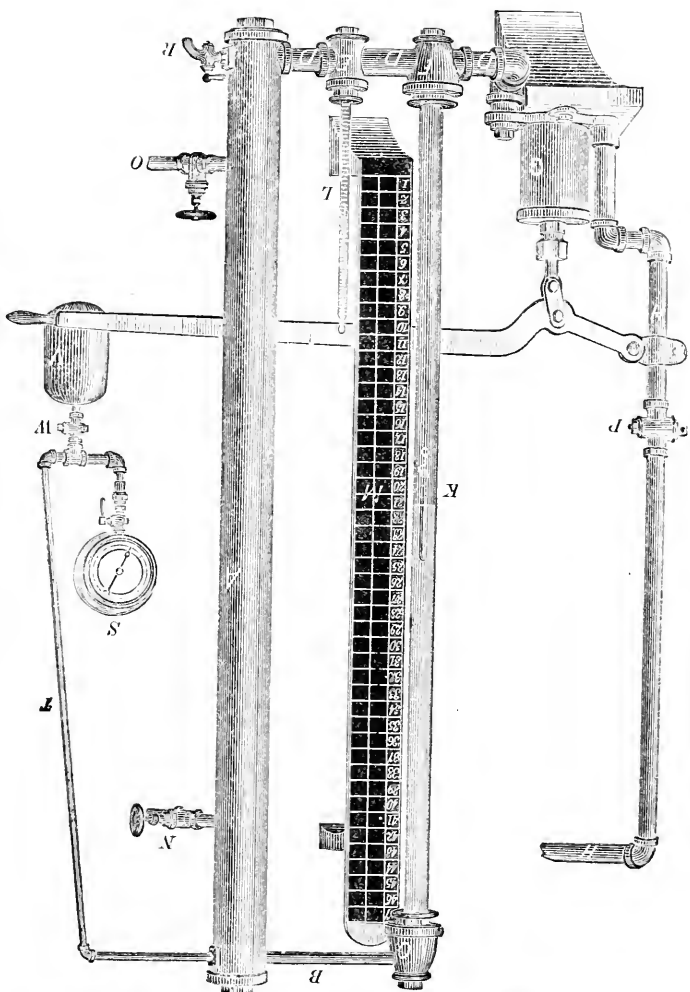
The apparatus is simple in construction and can be readily attached to any vessel, or still, in which liquids form the whole or part of the material being manufactured.

It is a novel combination of well-known instruments so arranged that it exhibits, under the same conditions as they exist in the vessel, the varying conditions of the material, so that at all times during the process of manufacture, the operator is informed concerning the following important points: Height or depth of material; the gallons in such quantities; the gallons in each inch and in any aggregate number of inches; temperature, both of material and its vapors; color and consistence; rate of evaporation and pressure of vapor.

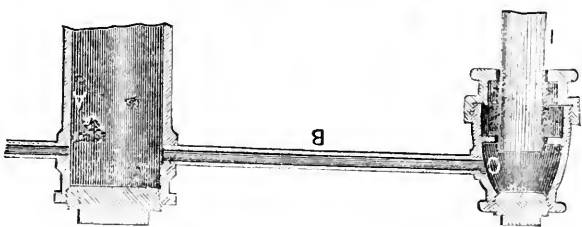
Its construction, as shown by the accompanying views, consists of a metal tube, A (with arms, B and D), attached to the vessel, in which the manufacture is carried on, by connections entering the vapor or steam space and at the bottom, with such further intermediate connections as may be found desirable, the same being controlled by the valve, N, and cocks, O. A thermometer, L, in the lower arm, D; a scale, M, graduated in inches with spaces for the contents in gallons of each inch, and for the aggregate contents from the bottom upwards; a glass tube, I, of width sufficient to act as a hydrometer jar; a float, K (placed inside of I), which can be either an alcoholometer, saccharometer, or such other kind of instrument as the material may call for; a pump, G, also connected to the vessel; a pressure gauge, S, and cock, R.

The manner of working it is as follows: The valve, N, connected with the vapor space is opened, heating the apparatus; any of the cocks, O (if more than the bottom one) may then be opened, and the liquid allowed to flow in. The pump, G, is then worked, which will carry a continuous stream past a mercury vessel, in which the bulb of the thermometer, L, is set, such stream being kept up until the mercury in the thermometer ceases to rise, showing the maximum heat for the time being. Then cease working the pump, allow the glass tube to fill; the liquid, in finding its level, will carry the float, K, with it; by means of that, and of the thermometer, the true gravity is made apparent. The color can be seen through the tube; the quantity by the scale, M, at line of the lead of the liquid, the pressure by the gauge, S, while, if it is desirable to raise the material away from the vessel, it can be drawn through the cock, R.

The temperature, gravity, quantity, color, consistence and pressure having been taken all at the same time, under the same conditions, the contents of the apparatus are returned to the vessel by closing the cock, O, and working the pump, G. The operation can then be immediately repeated, a few minutes being only necessary for the operation.



A NEW INDICATING APPARATUS.



Tin Discoveries on Lake Superior.—Some time since, the technical journals very generally circulated a circumstantial account, detailing the discovery of abundant and valuable deposits of tin on the north shore of Lake Superior, and purporting to be the result of personal examination of the field. As nothing either confirmatory or contradictory of this account has since appeared, it may be of interest to state that a correspondent of the *Engineering and Mining Journal*, who recently resided in the region of the alleged discoveries, writes to the editor a letter, in which he casts the gravest doubts upon their genuineness, and intimates that the whole statement bears the appearance of having been a systematically devised attempt at swindling.

New Method of Mounting Stereoscopic Views.—By PROFESSOR HIMES.—Instead of affixing the photographic prints to the usual stiff cards, they are mounted in a book, about $3\frac{3}{8}$ by $3\frac{1}{4}$ inches, on leaves of heavy paper of double that size, fastened by their centres on short guards, like maps in an atlas, each book containing about a dozen such double leaves. A piece of smooth paper is placed between the halves of each stereograph after mounting, and the book subjected to pressure, as of a copying press, for an hour or more. By opening such a book at any of these double leaves, and sliding it between the wire guards of a Holmes stereoscope, like an ordinary stereograph, an effect equal in all respects to that of the card stereograph is produced. Since the pictures can be readily examined by simply turning the leaves, and may be compactly stowed away, it is claimed that there is comparative freedom of the photographs from injury by mechanical, chemical, or atmospheric influences, whilst the facility of reference to any particular picture is greatly increased, especially when collections are properly arranged and classified; for which purpose each book is supplied with blank index and title pages. It is suggested that collections of stereographs on this plan, illustrative of different subjects, scientific and otherwise, or supplementary to books upon such subjects, might be placed in libraries, accessible to the public, with almost as little risk of injury as the books; a few simple instruments hung near such cases being the only addition necessary. The range of purely scientific subjects susceptible of stereoscopic illustration might increase under such encouragement.

The Artificial Production of Low Temperatures.—By PROF. EDWIN J. HOUSTON.—A need long experienced in science, viz: the

means of obtaining exceedingly low temperatures, seem at last to have been met by a German invention recently re-patented in this country. We allude to the "Windhausen Ice and Refrigerating Machine." Though introduced almost solely for practical purposes, mainly for the cheap production of artificial ice, the machine contains latent possibilities, which we hope will at once be utilized, that open up the most promising field to the original investigator, and bid fair to enrich science with stores of new facts.

Hitherto the lowest temperatures have been obtained through the rapid evaporation of solid carbonic acid dissolved in ether, or with liquid protoxide of nitrogen and bisulphide of carbon. These methods require much time, skill and caution, and are seldom employed. The Windhausen process, however, accomplishes the same result, with less trouble. A steam engine is employed to condense air to, say, two or three atmospheres. The heat developed by the compression is drawn off during the passage of the condensed air through pipes in a series of chambers, in which cold water is flowing. The cooled air is then allowed to expand into a cylinder under a gradually diminishing pressure, the expansion being attended with the development of great cold. It is claimed that under a pressure of but 35 pounds to the square inch, a reduction of — 54° F. has been obtained, a surprisingly low temperature, considering the means employed.

The following modifications of the apparatus would render its cold-producing power almost unlimited:—

1st. A communication between the expansion cylinder and the chambers through which the condensed air is conducted before it is allowed to expand. Supposing this outlet regulated by a cock, a blast of very cold air could replace the running water, and reduce the condensed air to a very low temperature.

2d. The introduction of a second compressing cylinder, with which the condensed air, after being cooled, could be still further compressed, again cooled, and finally conducted into the expansion cylinder. Under a pressure of, say, 60 atmospheres, a considerable mass of air at the temperature of say — 100° F. would, in its expansion, produce a reduction of temperature greater perhaps than any yet obtained. Since by means of the communication between the expansion and cooling chambers, the condensed air can be lowered to any temperature obtainable in the expansion cylinder, there would appear to be no other limit to the reduction of temperature save what would arise from the strength of materials, or the liquefaction and subsequent freezing of the nitrogen, or the oxygen of the air, or of the air itself.

Among the advantages that we may rationally expect to accrue from the apparatus thus modified, are the following :

1st. The confirmation or otherwise of the "absolute zero," as determined by the expansion or contraction of gases by heat or cold.

2d. The liquefaction and subsequent solidification of many of the incoercible gases, the determination of their physical peculiarities as liquids or solids, together with their crystalline form.

3d. The action of intense cold on the chemical affinities of certain gaseous compounds.

4th. The action of intense cold on the color of certain chemical compounds.—*Dept. Physics Central High School.*

Artificial Alizarine.—In substantiation of the growing importance of the manufacture of the artificial madder, referred to in a former item concerning the utilization of waste products, some remarks of Mr. J. W. Russell, before the Chemical Section of the British Association for the Advancement of Science, are directly to the point.

From his statements it appears almost certain that the industry of growing madder will shortly be extinguished altogether, and the lands and labor, now almost exclusively devoted to its cultivation in many parts of Germany and France, turned into other channels of production. Mr. Russell concludes his remarks as follows: "The alizarine mud, as I have called it, containing but tenper cent. of dry alizarine, is equal in dyeing power to about eight times its weight of the best madder, and is, moreover, the pure substances required for the dyeing in place of a complicated mixture (the natural madder) containing certain constituents which have a positively injurious effect on the colors produced. * * * * The demand for, and supply of, artificial alizarine are increasing at a most rapid rate, and yet its manufacture seems hardly to have commenced. The value of madder has much decreased; and, in fact, judging from what occurred in the year of revolution and commercial depression (1848), when the price of madder fell for a time to a point at which it was considered it would no longer remunerate the growers to produce it, that point has now again been reached, but certainly from a very different cause. Last year, artificial alizarine, equal in value to about one-fourth of the madder imported into England, was manufactured in this country. This year the amount will be much greater. Thus is

growing up a great industry, which, far and wide, must exercise most important effects. Old and cumbersome processes must give way to better, cheaper, newer ones; and, lastly, thousands of acres of lands, in different parts of the world, will be relieved from the necessity of growing the madder, and be ready to receive some new crop."

Iron Pyrites.—The *Polyt. Centralbl.* is responsible for the assertion, that iron pyrites may be so perfectly roasted as to retain only from one to two thousandths of sulphur, by roasting the ore, after having passed it once through Perret's roasting furnace, a second time, in a part of the same furnace, where there is fresh ore above and below it, which furnishes a high temperature in roasting. At the same time much more air must be given access to the ore, than in the first roasting. From the residue of the second roasting, it is said, a cast iron can be made, which is fit for use in the rolling mill.

Iron Electrotypes.—A brief item on this subject appeared in a former issue of the *Journal*, to which we may now add the additional declaration that M. Klein, a Russian chemist, has succeeded in obtaining very satisfactory results from a series of experiments in this direction.

The process followed by him is described as follows: The bath employed consists of a concentrated solution of sulphate of iron and ammonia; and the battery of four Meidinger cells. For an anode an iron plate is used, with a surface about eight times that of the cathode, and connecting this with a copper plate, a perfect coating of iron is obtained. On leaving the bath, the iron, it is said, is as hard as tempered steel, and very brittle. When heated, however, to a cherry red, it is said to become malleable, and may then be engraved as easily as soft steel.

Gain in Weight by Combustion.—At a recent lecture before the Franklin Institute, Mr. Theodore D. Rand showed a simple and satisfactory experiment to demonstrate the increase in weight of burning bodies, caused by their absorption of oxygen. About an ounce of fine turnings of zinc, produced in the spinning of that metal, were loosely wrapped with iron wire and suspended from the arm of a balance. The pan on the other arm having been weighted to counterbalance the zinc, the latter was ignited with a match. At first the combustion was rapid, and much oxide escaped in fumes, causing the zinc end of the balance to rise. Soon, however, the combustion be-

came a mere glow, the absorption of oxygen taking place without fumes. In about a minute the beam began to descend and soon very decidedly outweighed the counterbalance.

The only precaution necessary is to have the zinc moderately but not too compact. If too loose it burns too rapidly, if too compact it will not burn.

The National Academy of Sciences.—The following details concerning the formation, character and duties of this eminent body of scientific men, from the *Acta Columbiana*, may have some interest.

“The National Academy of Sciences was created by Act of Congress of the United States, approved March 3, 1863, to serve as an authoritative adviser of the Government upon all questions relating to science. The words of the Act imposing this duty are the following: ‘The Academy shall, whenever called upon by any department of the Government, investigate, examine, experiment and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments and reports to be paid from appropriations which may be made for that purpose; but the Academy shall receive no compensation whatever for any services to the Government of the United States.’ Practically, therefore, this body occupies the same position, as to scientific precedence, in this country as the Academy of Sciences of Paris, and the Royal Society of London, in France and Great Britain respectively.

“Many questions, among them some involving very laborious investigations, have been examined and reported on from time to time by Committees of the Academy, on the requisition of the several departments of the Executive Government, particularly the Departments of War, the Navy and the Treasury. Among them may be mentioned an inquiry into ‘the best means of improving the navigation of the river and harbor of San Juan del Norte, in Nicaragua,’ with a view of establishing a satisfactory inter-oceanic line of communication by that route. (This was before the opening of the trans-continental railroad.) Also inquiries into ‘the galvanic action arising from the association of zinc and iron;’ into ‘magnetic deviations in iron ships;’ into ‘the best means of testing the strength of distilled spirits;’ into ‘the merits of various schemes submitted to the Treasury by inventors, for the protection of the paper currency against counterfeits;’ and many others.

“Besides the reports to the Government, the Academy has made very numerous contributions to the advancement of science by the independent labors of its members, most of which have been published in scientific journals after having been read in the meetings; the pecuniary means at the command of the body not having sufficed to enable it to publish its own proceedings regularly in separate form. One volume was, however, published at the expense of the Government.

“By the Act of Charter, the number of members of the Academy was limited to fifty. On its own application this limitation was removed in 1871. The original corporators were named in the charter itself.

“Of the original members fourteen have been since removed by death, and five, at their own request, have been placed on the list of honorary members. The honorary members are Alexis Caswell, George Engelmann, Asa Gray, Joseph Leidy, and M. F. Langstreth; to whom are to be added Jas. P. Kirtland, a member since elected. One of the original corporators declined the nomination, and one other ceased to attend after the first meeting, and his name was dropped from the roll. There are now therefore only twenty-nine active members belonging to the original list.

“There have been added to the Academy by election, during the past ten years, fifty-three members, of whom six have died since their election, and one has been retired into the honorary list. There remain, therefore, of this number, forty-six active members, who, added to the twenty-nine original corporators, make the present total to be seventy-five. By a provision of the Constitution only ten additional members can be elected annually.

There have been also elected, since the foundation of the Academy eleven foreign associates, of whom four, viz: Sir Wm. Rowan Hamilton, Michael Faraday, Sir David Brewster, and Prof. G. A. A. Plana have died since their election.

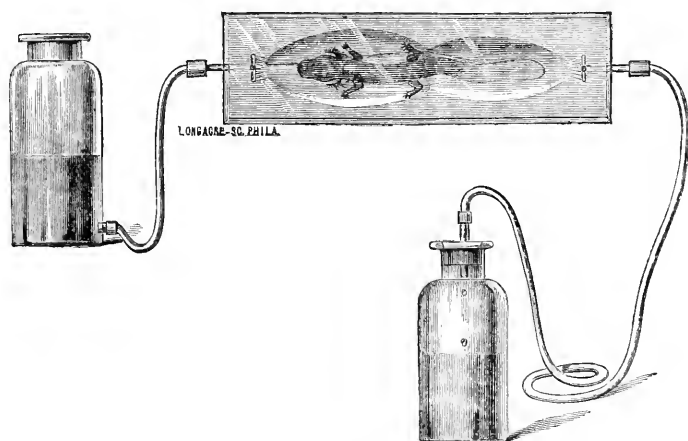
The Academy holds two *stated* meetings annually, one of which must be held in Washington, for the other the place is fixed by the Council. Scientific sessions may be called at any time and place, by a majority of the Council. The Council itself is a body composed of the officers of the Academy, and six other members elected for that purpose.

OPTICAL SECTION.

Proceedings of the Stated Meeting, November 24, 1873.

Several natural objects prepared for the microscope were furnished by Mr. T. W. Starr, of Philadelphia; also two delicate valves, made by Mr. Chabot, of this city, for preventing the gases used in combustion from mixing in their respective reservoirs, were shown attached to the elastic tubes.

The main subject of the meeting was the examination of Mr. D. S. Holman's "Siphon Slide," an engraving of which is herewith shown.



This invention presents a modification of the chamber of Mr. Holman's former device, known as the "Life Slide." It has fine perforations at each end of the chamber, too small to permit the escape of the animal under view, but sufficient to maintain a flow of water. These openings merge into cylindrical mouths, to each of which is attached a tightly-fitting elastic tube; one of these communicates with the reservoir of water, while the other acts as an escape conduit. The position of the slide, when in use, must be slightly *above* the level of the reservoir, while the escaping tube must rest *below* the reservoir; thus insuring a veritable siphon action in the apparatus, a constant flow of water being thus secured, in connection with the required atmospheric pressure for the retention of the cover of the slide. By this ingenious device, living aquatic animals may be retained in the chamber in a natural condition for hours, and even days.

Mr. Holman reported that he had exposed a young larva of Salamander, for an hour, to the full influence of the oxyhydrogen light, with no apparent injury to the subject.

By a critical watching of the screen, the circulation of the blood in the minute arteries of the animals was clearly visible to the members—a result, it is believed, never hitherto presented to an audience during such an extended period of observation.

The lantern, as a whole, is the work of Mr. Joseph Zentmayer, also a member of the Section, who, besides building the various parts with his peculiar exactness, furnished with it a lens of eight-tenths of an inch in focus, of a novel construction.

[COMMUNICATED.—The “Holman Siphon Slide,” partially described in the minute of the Recorder of the Optical Section of the Institute, is an invention the want of which has been felt by all teachers and students in histological studies. By its means a constant current of either cold or hot water, adjustable at will, may be caused to flow across the stage of the microscope without interruption for hours or days together, thus giving a convenient means of leisurely studying the circulation of the blood, with its attendant phenomena, in many animals, without the slightest exhaustion of respiration, and without *curara* or *chloral*, which narcotics always create pathological conditions unfavorable for such observations.

The migration of white-blood corpuscles in tissues not mutilated, the phenomena of inflammation, the delicate nerve fibres in *living* tissues, living epithelium, and many types of aquatic respiration, fresh-water or marine, are all brought within easy study of every teacher or student.

I have had under observation for a week, in one of these slides, a larva of a Chironomida, and besides the beautiful spectacle of its blood-red organization, I was able to watch its habit of weaving a silken tube under water in order to inhabit it for protection against its enemies.

When opticians shall give us lenses of power and light enough to be used successfully in the oxyhydrogen or electric lantern, this contrivance will render it possible to keep even a living trout, just hatched from the egg, under the beam of illumination for hours, if desirable, without exhaustion, because a constant current of ice-cold water may be drawn over the animal by the siphon action of the slide.—J. G. H.]

Civil and Mechanical Engineering.

TEST OF A STATIONARY ENGINE.*

A few preliminary remarks on the test described in the accompanying report may not be out of place. A pair of high pressure engines—diameter of cylinders, 20 inches; length of stroke, 4 feet—were fitted with a patent condenser, under the guarantee that several tons of coal would be saved per week, it being understood that all leaks of joints, valves, pistons, etc., were to be repaired by the proprietor. An inspection of the coal account, after the condenser was attached, showed that the consumption of coal was increased, and the engineer insisted that there were no leaks, and that the whole fault was with the condenser. The condenser in question has already obtained considerable reputation, and is in use in various parts of the country, giving good satisfaction. It was necessary, however, to bring facts to bear in a case like this, and to show the existence of leaks beyond controversy. In this regard, the report will speak for itself, the test having determined an enormous drain of steam, palpable to the senses, and capable of being measured and weighed. It scarcely ever happens that users of steam power are not amply repaid for the cost of careful investigations, and this report is published in the hope of calling attention to the importance of such tests. There is a tendency among persons who are proud to call themselves “practical” to decry all theory, but we think the reader will find the accompanying remarks quite practical enough, since they contain suggestions readily appreciated by the most practical man, in reference to the folly of generating steam by the consumption of fuel merely to blow it away without using it. If a man were to get up a high pressure of steam in a boiler for the pleasure of seeing it escape through the safety valve, his acquaintances would have their opinion of his sagacity. How many to-day are doing essentially the same thing, unwittingly:

80 BROADWAY, NEW YORK.

Henry L. Brevoort, Esq., New York: SIR.—As requested by you, I visited the works of the Peters Manufacturing Company, at Newark, N. J., on the 18th and 19th instants, and made careful tests of

*From The Iron Age.

the engines, to discover if there were any leaks or other derangements. On the 18th inst. the condenser was used, and on the 19th it was detached, the steam from the engine being allowed to exhaust into the atmosphere. In making these tests I took 12 indicator diagrams each day (3 from each end of each cylinder), at suitable intervals, so as to obtain average conditions. I also noted down various other data, as will appear in the course of my report. According to memoranda furnished to me, the consumption of coal for three days, when the condenser was in use, was at the rate of 14,667 pounds per day—and for three days when the condenser was detached, at the rate of 12,667 pounds per day—showing a gain in fuel by taking off the condenser of 15.79 per cent.

During the two days I was at the works, the conditions, in regard to the power developed by the engines, were nearly identical, an average of all the cards taken on the 18th instant, when the condenser was attached, giving a mean pressure on the piston of 30.9 pounds per square inch, and 199.6 indicated horse-power, while on the 19th instant, when the condenser was taken off, the average mean pressure was 29.0 pounds per square inch, and the indicated horse-power 198.44.

I have taken from the cards the amount of steam used per indicated horse-power per hour, adding to those taken on the 18th instant the amount of steam used by the air-pump. In making this calculation I have used the pressure of the steam in the cylinder, as shown by the cards, at the time the exhaust valves opened, and have multiplied the number of strokes made by the pistons per hour by the volume of that portion of the cylinders swept through by the pistons, from the commencement of stroke to point of exhaust (in cubic feet with clearance added), and by the weight of a cubic foot of steam at the given pressure, thus obtaining the number of pounds of water, in the form of steam, used by the engines per hour. The cards, of course, do not show all the steam used in the cylinders, as they do not give the amount of water in the steam, the amount of radiation and condensation, and the amount of steam that leaks past the valves when the cylinder is opened to the exhaust. But under the present circumstances they give good comparative results.

As shown by these calculations, the amount of water per indicated horse-power per hour (adding that required to work the air-pump), on the 18th inst., was 23.18 pounds. On the 19th inst., the amount of water required per indicated horse-power per hour was 26.98 lbs.

According to this, it appears that the engines, when exhausting into the air, required an evaporation of 16·39 per cent. more water to enable them to do the same work as when using the condenser, and did this with 15·79 per cent. less coal.

A conclusion so anomalous could only be reached by ignoring the question of leaks around the engines, unless the loss was caused by some defect in the condenser.

There are only two ways in which the use of the condenser could occasion a waste of fuel: 1st. By creating additional back pressure, instead of lessening it. 2d. By using more power to work the air-pump than would compensate for the vacuum produced. I will examine both of these points.

From the indicator cards taken, the mean pressure per square inch, due to a vacuum when the condenser was in operation, was ascertained to be 5·14 pounds, and the mean back pressure per square inch 2·29 pounds, so that the condenser, instead of increasing the back pressure, reduced it to the extent of 7·43 pounds per square inch, or at the rate of 24·44 per cent. of the total mean pressure on the pistons.

In regard to the second point, the average speed of the air pump was 136 strokes per minute, and calculating from its piston displacement, the most water it could have delivered in that time was 6181·5 pounds. This water had to be lifted a distance of 14 feet, so that the work required from the pump, at its maximum, would be about 2·62 useful horse-power. As will appear further on, very much less than the maximum quantity of water was actually delivered by the pump.

When the engines were running without the condenser, the steam was exhausted through three feed water heaters, thereby increasing the amount of back pressure. Credit should be given for the increased heat of the feed water, since, when the condenser was in use, the exhaust steam only passed through one heater, and the feed water did not have so high a temperature. Means of a number of observations of the temperature of the feed, gave the following results:—

June 18,	141·5°
June 19,	169·4°
Difference,	27·9°

The amount of gain from the increased heat of feed water is readily calculated. The mean pressure of the steam per gauge, on the 19th

instant, was 80·6 pounds per square inch. Steam of this pressure has a total heat of 1209·3°. Hence with the feed water at 141·5°, a pound of water must have 1067·8 units of heat imparted to it by the fuel to be converted into steam, and when the feed water is at 169·4° it will require 1039·9° units of heat. The per cent. of gain by the increased heat of the feed water will be

$$\frac{(1067.8 - 1039.9)}{1067.8} \times 100 = 2.67.$$

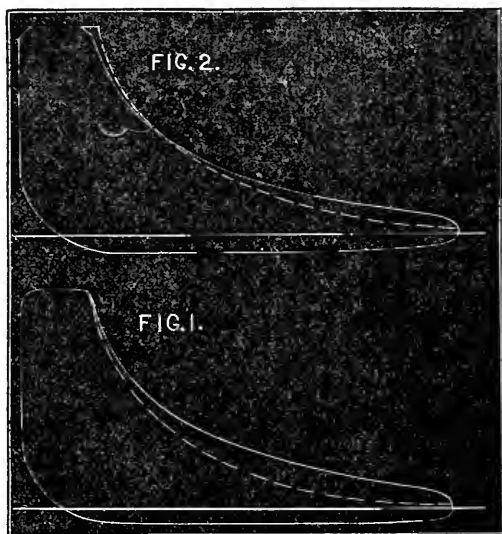
The gain by the use of this arrangement of heating feed water is somewhat questionable. The back pressure produced by exhausting through the heaters, is 2·29 pounds per square inch, or 9·7 per cent. of the total mean pressure on the pistons, and produces a saving of 2·67 per cent. In other words, nearly 10 pounds of coal are burned in order to save 3.

It will be advisable, then, to return to the engines, and endeavor to discover leaks of steam. It must be evident that if valves and pistons are tight there can be no steam admitted to the cylinder after the steam valve has closed, nor can any be lost from it until the exhaust valve is opened, and under ordinary circumstances the indicator will show if these conditions obtain in actual practice. I give a tracing of an indicator diagram (Fig. 1), taken on the 18th inst., and have added a dotted line, showing approximately the form of expansion curve if valves and pistons had been tight.*

The marked difference between this curve and the one actually produced is still more noticeable in most of the other diagrams, showing conclusively the existence of an excessive leak either in steam valve (Fig. 2), or in joint of steam chest. Below will be found a tracing of the same diagram, with a dotted line, showing the form of expansion curve, with valves, etc., in good condition, the mean pressure on the piston being the same in the actual and theoretical diagrams. Mere inspection of this card will show that the same amount of work will be done with far less steam, if the card is taken as marked by the dotted line, and a calculation gives 18·37 per cent. less steam to do the same work, if the engines performed as indicated by the dotted line.

* As is well known to engineers that, even if valves and piston are tight, the actual curve of expansion may be higher than the theoretical, owing to condensation and re-evaporation, or from the presence of a large quantity of water in the steam, I would not so confidently have attributed the difference in this case to leaks, unless subsequent tests (as shown in the report) had confirmed this view.

But this waste of steam is small in comparison with that lost when the engine is exhausting. If there is a leak of valves or steam chest while the cylinder is taking steam, this becomes far worse when the pressure is diminished by the exhaust. A good idea of the state of things existing in these engines can be obtained by imagining a steam pipe to be tapped into the cylinders for the purpose of admitting steam continually, during both the periods of admission and exhaust in the cylinders.



The steam valves of these engines close quickly, and it is easy to calculate the difference in the amounts of steam in the cylinders at points of cut-off and exhaust. The mean of all the diagrams shows a difference of 75.5 per cent., or, in other words, that while the pistons are moving from point of cut-off to point of exhaust, 75.5 per cent. as much of steam leaks in as was previously admitted. Of course when the exhaust valve is opened a still greater leak takes place under the diminished pressure. Fortunately I was able to determine the amount of this leak (which the indicator does not show) quite accurately.

On the 18th instant, while the engines were stopped, a simple test showed that the pistons were not tight, but the amount of leak from that cause is not to be compared with the one already pointed out. So large a leak can hardly be due to the improper fitting of the steam

valves, and I am of the opinion that it will be found in some portions of the steam chests which have several internal joints.

I will now describe the method by which I ascertained the amount of leak that occurred during the exhaust. When the condenser was in operation the condensing water and the condensed steam were discharged by the air pump into a large tank. This water entered the condenser at a temperature of 71° , and was discharged at a temperature of 124.5° , having acquired 53.5° from the condensed steam. I obtained the quantity of water discharged by the air pump per minute by observing the time required to fill a tub of known dimensions held under the discharge pipe. An average of seventeen careful experiments of this kind gave the time of filling the tub as 3.37 seconds, and, in addition, some little water splashed over at each experiment, owing to the violence of the discharge. I certainly err on the side of safety in assuming the time as $3\frac{1}{2}$ seconds. The capacity of the tub was 4521.37 cubic inches, which would give a discharge per minute of 335.5 gallons, or 2792.19 pounds. Somewhat more water per minute was undoubtedly discharged, but in the absence of exact measuring apparatus, a perfectly safe estimate, assuredly within the limits, seems advisable. Good steam pumps will deliver from 90 to 95 per cent. of the quantities due to the displacement of pump pistons, and the quantity I have taken is only about 45 per cent. of the maximum.

The calculations of the amount of steam used, from measurements of the quantity and temperature of the discharge water, is one of the most elegant and accurate tests of the efficiency of an engine; and it is rarely that so good an opportunity for obtaining these data is secured without considerable preparation.

The amount of water delivered per minute, as before remarked, was 2792.19 pounds, and its temperature was raised 53.5° . The method of obtaining the amount of steam used by the engines per minute from these data is as follows:

Let X = pounds of steam used per minute.

Let W = pounds of condensing water.

Then from the observation,

$$W + X = 2792.19.$$

$$W = 2792.19 - X.$$

The steam at the point of exhaust had a mean pressure, as shown by the indicator diagrams, of 19.5 pounds per square inch, so that each pound of steam contained 1183.1 units of heat. When con-

densed the temperature of this steam was 124.5° , so that each pound had imparted $1183.1 - 124.5 = 1058.6$ units of heat to the condensing water, and by this means had raised its temperature 53.5° .

From these considerations an equation can be formed, and the amount of steam used per minute determined.

$X \times 1058.6 = \text{units of heat lost by the steam.}$

$W \text{ or } (2792.19 - X) \times 53.5 = \text{units of heat imparted to condensing water.}$

And as these must be equal

$X \times 1058.6 = (2792.19 - X) \times 53.5.$

Whence

$X = 134.32.$

This 134.32 is the number of pounds of steam used by the engines and air pump per minute, and we must next ascertain the amount of steam used by the air pump. The useful work of the air pump is the lifting of 2792.19 pounds of water 14 feet high per minute, which amounts to

$$\frac{2792.19 \times 14}{33,000} = 1.18 \text{ horse power.}$$

Beside this useful work, the pump must overcome the friction of its moving parts, and the friction of the water in the passages. At a careful test of steam pumps at the fair of the American Institute in 1867, the Knowles pump gave an efficiency of 44.38 per cent., one pump of another make giving as low an efficiency as 18.33 per cent. I will assume this lowest efficiency for the present case. On this supposition, to produce 1.18 horse-power of useful work, the pump must have an indicated power of

$$\frac{1.18 \times 100}{18.33} = 6.49.$$

(It is proper to remark here that, according to the efficiency of this pump, as shown by experiments, the indicated horse power would only need to be 2.66, and it will be evident that I have allowed an excessive margin of safety). The mean pressure of steam required to produce this horse-power at the speed at which the pump was working, is 15.12 pounds per square inch, and allowing a back pressure on the piston of 9 pounds per square inch, the pressure per gauge should be 24.12 pounds—say 25.

On this assumption the pump would require 6.49 pounds of steam per minute, which is an allowance of nearly a cubic foot of water per

indicated horse-power per hour. The amount of steam used by the engines per minute will then be $134.32 - 6.49 = 127.83$. According to the indicator diagrams, the amount of water used by the engines per indicated horse-power per hour was 21.23 pounds, and this calculation shows the amount actually used to be 38.43 lbs., giving a leak while the engines were exhausting of 81.02 per cent.

This is quite sufficient to account for the apparent paradox mentioned in the first part of this report, of the engines, when the condenser was detached, using more steam and burning less coal. I had no means of ascertaining the amount of steam that leaked during the exhaust, when the engines were disconnected from the condenser, but of course it would be less than when the condenser was in operation, since in the latter case the pressure of the exhaust was much diminished.

It is a matter of surprise that the condition of affairs was not discovered long ago by a simple inspection of the coal account. Here is a case in which, under the most moderate estimate, 50 per cent. of the effect of the fuel has been passing silently away, unseen and unsuspected, without doing any useful work. It is another illustration of the fact which is so frequently demonstrated, that users of steam power cannot employ too many checks to prevent and discover waste; and it is a strong tribute to the value of that useful instrument—too often despised by the so-called practical man—the steam engine indicator. I assume that the owner of these engines will seize the first opportunity to have this great leak stopped, and I am confident that when this is done, he will realize the full benefit claimed by you for the application of the condenser. I must add, before closing, that I have carefully examined the construction and operation of the condenser, in connection with my inspection and test of the engines, and it gives me pleasure to state that it seems to be well designed and constructed, and of ample proportions.

Respectfully,

RICHARD H. BUEL.

June 24, 1873.

ON THE STEAM BOILER EXPLOSION ON THE FOURTH AVENUE, BETWEEN 128TH AND 129TH STREET, N. Y.

BY W. BARNET LE VAN, Engineer.

At the time of the explosion the boiler stood in the middle of the roadway between 128th and 129th street, on Fourth Avenue.

It was attached to a hoisting machine, and the men employed upon it were in the act of moving the apparatus further up the street.

The whole apparatus, boiler and hoisting machine, stood on a wooden platform, supported by heavy broad tread wheels. It was used in hoisting earth from the excavation and depositing the same on the bank above.

The explosion occurred about four o'clock P. M., on Tuesday, November 11th, 1873, killing seven persons and wounding nine others.

Very considerable damage was done to the houses in the neighborhood by the concussion and flying missiles. The windows of every store and many of those of the residences above them along the block facing the boiler were broken, shutters were torn asunder and their fragments scattered broadcast. Broken glass and fragments covered the sidewalks, and such of the shopkeepers as had whole shutters closed their places.

The exploded and mutilated boiler was found amid beams and broken timbers, a chaos of woodwork that told a tale of recent disaster.

The boiler is what is known as a vertical tubular, consisting of a shell about 6 feet in height and 44 inches in diameter, made up of two rims, the thickness of which, as well the heads, was No. 4 = to .238 inches.

It differed somewhat from the ordinary upright boiler, in having two systems of tubes; the lower set consisting of a cluster of forty-two water tubes, each two inches in diameter and twenty-five inches long, connecting the front and back water-spaces, passing directly above the fire, from front to rear, and placed about five-eighths of an inch apart and staggered so that the hot gases in passing up between impinge on them. The vertical fire tubes, thirty-six in number, two inches in diameter and seventeen inches long, connected the upper end or crown sheet of the furnace with chimney. Through these tubes the products of combustion passed, after passing between the water tubes below; the upper flue sheet was stayed to the top rim by braces about eight inches apart, in it was placed the man-

hole, strengthened by a cast-iron rim riveted to it and fitting the cover.

It had two gauge cocks, the bottom one about three inches above the top, also one safety valve, one and one-half inch diameter.

The water was carried in the boiler so as to cover the lower flue sheet of the upper fire tubes, (it was claimed that the water could be carried much lower without danger of burning out the crown sheet, because the heat was so exhausted by the water-tubes, before passing them, that it could not injure the tube-sheet above.)

The condition of the boiler after the explosion shows the crown-sheet of the furnace and all the vertical fire-tubes to be in good condition, and does not indicate overheating, except at the extreme upper ends. The vertical tubes are in the same position as when first placed in the boiler, with the exception of the flanged ends securing them to the upper tube-sheet, which are straightened out and drawn a little to one side by the withdrawal of the tube-sheet from them.

From an examination of the portion of the boiler remaining in its original position, it parted on a line of the caulking of the seam that joined the two rims together, starting on the back side of the boiler and following in a horizontal line two-thirds of the circumference and running in to the front sheet as shown in the cut.

The weakest part of the boiler was at the point of the commencement of the rupture; the boiler-maker, in caulking this seam, indented the sheet with his caulking tool to the depth of at least one-thirty-fourth of an inch, reducing thereby the thickness of the plate. The line of the fracture follows this indentation all the way.

Pieces of the shell and upper flue sheet, thrown upward and two blocks distant, went through the roof of a house and lodged in the top story; the balance, consisting of braces and smoke-box, were thrown in all directions.

One of these projectiles was thrown towards one hundred and twenty-seventh street, and struck a young lady, Miss Louisa Bassford, aged eighteen, killing her instantly. She fell on the sidewalk where she stood at the moment of receiving the blow. The upper half of her skull was carried some ten feet distant; her head was literally cut in two. A little Italian girl, Irene Benetre, aged twelve, carrying a harp across the bridge at one hundred and twenty-eighth street, was killed about midway in her passage over the avenue; William Britt, ten years of age, on his way home from school, met his death

in the same place; as did also four of the men employed on the work. Curiously enough, all the killed and wounded were struck in the head.

From all the information that could be obtained, it was shown that prior to the explosion there was about forty pounds pressure of steam per square inch on the boiler, water to the second gauge cock had been pumped in some twenty minutes, and the furnace door was open. The engine was at rest, and the whole apparatus had been moved about ten feet.

The Engineer's Statement.—John Barnum, the engineer, said: I have had fifteen years experience; I was licensed two months ago; I passed an examination before I received my license. The boiler exploded about four o'clock; I was at 129th street, coming toward it. About twenty minutes to four, I was at the boiler and pumped it up. I threw the fire door open. The boiler was in good condition to be moved. Never had orders to stand by the boiler while it was being moved. I consider the moving perfectly safe. There was no crack in the boiler that I could see. When I left the boiler the gauge showed fifty pounds. The steam and water gauges were in good condition.

John Daggert's, (the man in charge of the hoisting machine), statement.—Two weeks before the explosion I was set to work at the hoister. I was placed under the orders of John Barnum, the engineer, and the machine was never moved except at his direction. Before the machine was moved that afternoon, Barnum said the boiler was all right. When the explosion came, I was standing still, having moved the machine about ten feet. There were a number of workmen around the boiler; I was about four feet from it. I heard a great noise. It was the work of a moment. If buildings had fallen over my head and been smashed to pieces, that would have been as near as I could come to a description of the explosion. I was knocked down. I don't remember anything else until somebody lifted me on my feet; then I found my coat was saturated with steam and I was scalded about the neck. I saw some dead bodies on the ground, one on each side of me. My foot rested on one of them.

In reply to the foreman of the jury, the witness said: I don't think there was any fuel put in the fire box just previous to the removal of the boiler; the fire door was open; I saw it; that was to stop the draught and let the fire go down. Just previous to the explosion I tried the water gauge, and found water in the upper gauge cock; as

far as I remember, the pressure was forty pounds just before the explosion; I saw it on the steam gauge. The last thing done previous to the removal was to pump water into the boiler. Barnum left me about fifteen minutes before the accident; when we were at work, the pressure on the boiler was sixty or seventy pounds.

The cause of the explosion was over-pressure.

It is a well-known fact that all water is surcharged with atmospheric air; the effect of this air in the water is that it promotes the ebullition pushing the atoms apart, as it were, and aiding them to take the gaseous form. Water freed from air by long boiling has its cohesive character entirely changed, thus removing the air cushion which separates the atoms; this is demonstrated by the water-hammer, of every day occurrence, in the water-pipes of our houses on the sudden shutting off of a stopcock, showing how it assumes almost the character of a solid.

Water thus freed of its air may be raised more than 100 degrees above the boiling point without ebullition.

When ebullition does take place in water so freed of air—it having an enormous excess of heat stored up—it is converted into explosion like the violent breaking of a spring under strong tension.

We can compare the presence of heat stored up as latent in a body of water to a bottle of soda charged with carbonic acid gas, the gas being held down by the attraction of the atoms of the water is not readily discharged without an agitation of the bottle. Pour the soda into a tumbler, when it has subsided dash in some fine sand, and a violent effervescence is due entirely to a mechanical disturbance.

Now, applying this to the boiler before us, it had been standing still for a long time, no doubt sufficiently long to expel the air contained in its water; *that* liquid would possess, in a greater or less degree, the high cohesive quality to the above.

Now by the moving of this boiler over the rough road-way, jolting it would have a tendency to lift the safety-valve, thereby disturb the attraction of the liquid particles for each other, and steam of explosive force would instantly be generated.

That there was at the time of rupture an excessive pressure in the boiler, the condition of the remaining portion is the best evidence. Not one of the vertical tubes are distorted in the least; they remained perfectly perpendicular as when first placed in the boiler, in fact all the parts remaining are as perfect as when first made.

The boiler inclines toward 129th street, showing that the weakest

part of the shell was on the back side, the front side being the stronger, as shown by the irregular fracture which caused it to incline up the avenue.

DESCRIPTION AND DUTY OF THE LYNN PUMPING ENGINE.

The following communication from a correspondent, is a description of the engine now in operation at the water works of the city of Lynn, Massachusetts.—ED.

Description of the Pumping Engine.—The economy of the Lynn pumping engine has exceeded all machines of its class hitherto constructed in this country. On account of its novel design and many peculiarities of construction, we will give a short description of its operation. The cylinders are placed in the central part of the engine, and connect with the extremes of the walking beam; the pump is located directly under one end, and the crank, connecting with the fly wheel, beneath the other. This arrangement allows the stroke of both cylinders, the pump and the throw of the crank to be of the same length, therefore all the reciprocating parts move with the same velocity, and their momentum is exactly proportional to their weight—a method of construction which is philosophical in principle. This arrangement reduces the strain on the various parts of the machine, diminishes the friction, and permits a reduction of the weight of matter used in construction. It also contributes largely to the steadiness of motion. A series of computations show the stress on the walking beam to be only twenty-five per cent. of what it would be were the cylinders and pump arranged as is customary in such engines.

The steam from the boiler passes into the high-pressure cylinder, and when the piston has advanced one-third of its full stroke, the port is closed, and the steam impels the piston by the gaseous property of expansion, its volume being increased three times, and the pressure diminished proportionally. When the stroke is finished, the steam passes into the low-pressure cylinder, which is nearly four and one-fourth times as large, and operates in a similar manner; thence it goes into the condenser. In passing through the two cylinders the steam is expanded twelve and three-fourths times its original volume.

By an indicator diagram, taken by the writer, the mean pressure on the piston of the high-pressure cylinder was found to be forty and eight one-hundredths pounds per square inch, while that on the piston of the low-pressure cylinder amounted to twelve and eight one

hundreds pounds per square inch; but on account of the increased capacity of the low-pressure cylinder, the total pressure was twenty-four thousand four hundred and sixty-three pounds, being nearly thirty-five per cent. more than that on the high-pressure cylinder, which amounted to eighteen thousand one hundred and fifty-six pounds. The cylinders are surrounded by steam jackets, and are further protected from a loss of heat by radiation by a covering of asbestos. Outside of this is a casing of black walnut.

The horse-power of the engine varies from ninety to two hundred, according to speed. The small pumping engine in the boiler-room, which is judiciously kept there as a reserve in case of accident, consumes from six to seven times as much coal as the large engine when doing the same work. The pump throws one hundred and ninety-four and ninety-three one-hundredths gallons per stroke into the reservoir, which is one hundred and fifty-seven and six-tenths feet above the surface of the water in the pump well.

The duty of an engine is the measure of its economy, and consists of the number of pounds of water raised one foot high by the consumption of one hundred pounds of coal. To substantiate the claim made in the first part of this article, we give the duties of such city pumping engines as we are enabled to from the various reports in our possession. When a test has been made by a board of expert engineers upon any engine, the results obtained should be taken in preference to those contained in the report of those having the charge of the engine. The report of a board of experts generally exceeds the monthly duty of an engine by about twenty-five per cent., because in the latter case coal is used in starting and banking fires, also for heating the building.

The highest duty given by the Lynn engine took place between June 27, at six o'clock A. M., and fifteen minutes past eleven on the following day—twenty-nine and one-fourth consecutive hours—during which the engine made twenty thousand four hundred and forty revolutions, and consumed fifty-four hundred pounds of coal. The duty for the five months ending September 30, including coal used for starting and banking fires, amounted to seventy-nine millions. The following table gives figures confirming our statements:

Place.		Pounds.
Cincinnati, No. 6,	} Trial	22,937,747
	} Year 1871	21,439,332
Boston Highlands,	Year 1872	22,770,000

Cincinnati, No. 5.	} Trial	32,946,758
	} Year 1871	30,794,446
Cincinnati, No. 4.	} Trial	34,053,856
	} Year 1871	31,229,288
Louisville, Year 1871	. . . . .	36,915,404
Salem, Year 1872	. . . . .	36,061,926
Cincinnati, No. 3.	} Trial	38,976,138
	} Year 1871	36,430,022
Cleveland, Year 1871	. . . . .	40,941,937
Chicago, Year 1871	. . . . .	44,465,198
Cambridge, Year 1872	. . . . .	39,008,782
Cambridge, March, 1873	. . . . .	52,000,000
Phila. (Belmont)	} Trial	54,416,694
	} Year 1872	41,000,000
New Bedford, Trial	. . . . .	59,336,497
Brooklyn, No. 1, Trial	. . . . .	61,111,400
Charlestown, No. 3, November, 1872	. . . . .	62,069,280
Charlestown, Nos. 1, 2 and 3, Year 1872	. . . . .	54,259,482
Brooklyn, No. 3, Trial	. . . . .	72,000,000
Lowell, Trial	. . . . .	93,002,272
Lynn, five months	. . . . .	78,865,000
Lynn, June 27 and 28	. . . . .	99,428,000

CIVIL ENGINEER.

THE PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

By J. RICHARDS, Mechanical Engineer.

[Entered according to the act of Congress, in the year 1873, by John Richards, in the office of the Librarian of Congress at Washington.]

(Continued from Vol. LXVI, page 395.)

SHAFTS FOR TRANSMITTING POWER.

There is no use in entering upon explanations of what the learner has before his eyes. He sees shafts wherever there is machinery; he may also see the extent to which they are employed to transmit power, and the usual manner of arranging them; he can read in various text-books of the exact data for determining the amount of torsional strain that shafts of a given diameter will bear; that their capacity to resist torsional strain is as the cube of the diameter, and that the deflection from transverse strains is so many degrees, with many other matters that are highly useful and proper to know. I will therefore not devote any space to these points here, but treat of some of the more obscure conditions that pertain to shafts, such as

are demonstrated by practical experience rather than deduced from mathematical data. What is said will apply especially to what is termed line-shafting, for conveying and distributing power in machine shops and other manufacturing establishments.

The strength of shafts is governed by their size and the arrangement of their supports.

The capacity of shafts is governed by their strength and the speed at which they run, taken together.

The strains to which shafts are subjected are the torsional strain of transmission, transverse strain from belts and wheels, and strains from accidents, such as the winding of belts.

The speed at which shafts should run is to be governed by the nature of the machinery to be driven and the nature of the bearings in which the shafts are supported.

As the strength of the shafts is determined by their size, and the size fixed by the strains to which the shafts are subjected, the strains are to be first considered

There were three kinds of strain mentioned—torsional, deflective, and what was termed accidental strains.

To meet these several strains the same means has to be provided, which is a sufficient size in the shafts to resist them; hence it is useless to consider each of these different strains independently. If we know which of the three is greatest, and provide for that one, the rest of course may be disregarded. This, in practice, we find to be the accidental strains to which shafts are subjected, and they are always made in point of strength far in excess of any standard that would be fixed by either the torsional or transverse strain due to the regular duty the shafts have to perform.

This brings us back to the old proposition, that for structures that do not involve motion mathematical data will furnish dimensions, but the same rule will not apply in machinery.

Experience has demonstrated that for ordinary cases, where the power transmitted is applied with tolerable regularity, that a shaft three inches in diameter, with its bearings four diameters in length, placed ten feet apart, and running at a speed of one hundred and fifty revolutions a minute, is a proper size to transmit fifty horse-power.

The apprentice, by assuming this or any well-tried example, and estimating larger or smaller shafts by keeping their diameters as the cube root of the power to be transmitted, the distance between bearings as the diameter, and the speed inversely as the diameter, will find

his calculations to agree with the modern practice of our best engineers.

Shafts as a means for transmitting power afford the very important advantage that power can be easily taken off at any point throughout their length by means of pulleys or gearing, also in forming a positive connection between different machines.

Shafts are also the cheapest means of transmitting power within limited distances.

The capacity of shafts in resisting torsional strain is as the cube of their diameter, and the amount of torsional deflection in shafts is as their length.

The torsional capacity being based upon the diameter, often leads to what may be termed tapering shafts, lines in which the diameter of the several sections are diminished as the distance from the driving power increases, and as the duty to be performed grows less.

This plan of arranging line shafting has been and is yet quite common, but certainly was never arrived at by any of the processes of reasoning that have been so continually alluded to in the course of this treatise.

Almost every plan of construction has both its advantages and disadvantages, and the best means of determining the excess of either, in any case, is to first arrive at all the conditions, as near as possible, then form a "trial balance," putting the advantages on one side and the disadvantages on the other, and foot up the sums for comparison.

Dealing with this matter of shafts of uniform diameter and shafts of varying diameter in this way, we find in favor of the later plan a little saving of material and a slight reduction of friction, as advantages; the saving of material relating only to first cost, because the cost of fitting is greater in constructing shafts when the diameters of the pieces are varied; the friction, considering that the same velocity throughout must be assumed, is scarcely worth estimating.

For disadvantages, there is the want of uniformity between fittings that prevents their interchange from one part of the shaft to the other, a matter of great importance; a shaft, when constructed in this way, is special machinery, adapted to some particular place or duty, and not a standard product that can be regularly manufactured as a staple, and thus afforded at a low price. Pulleys, wheels, bearings and couplings have to be all specially prepared, and, in case of change or extension of lines of shafting, causes annoyance, and frequently no

little expense. The bearings, besides being of varied strength, are generally in such cases placed at irregular intervals, and the lengths of the different sections sometimes varied to suit the diameter of the shafts.

Going next to shafts of uniform diameter, everything pertaining to the line is interchangeable; the pulleys, wheels, bearings or hangers can be placed at pleasure, or changed from one part of the works to another. The first cost of a line of shafting of uniform diameter, strong enough for a particular duty, is generally less than that of one consisting of sections that vary in size, and all the objections of diminishing that have been named are avoided.

I have called attention to this case, as one wherein the conditions of operation obviously furnish the true data to govern the construction of machinery, instead of the strains to which the parts are subjected, and as a good example of the importance of analyzing mechanical conditions.

If the general diameter of a shaft was predicated upon the exact amount of power to be transmitted, or if the diameter of a shaft at various parts was based upon the torsional stress that would be sustained at those points, such a shaft would not only fail to meet the conditions of practical use, but would cost more by such an adaptation.

The regular working strain to which shafts are subjected is inversely as the speed at which they run; a strong reason in favor of arranging shafts to run at a maximum speed, if there was nothing more than first cost to consider; but there are other, and more important conditions to be taken into account. Principal among them is the required rate of movement when power is taken off, and the endurance of bearings.

In the case of line-shafting in manufactories, if the speed varied so much from the first movers on the machines as to require one or more intermediate or countershafts, the expense of fitting in this manner would be very greatly increased; on the contrary, if countershafts can be avoided, there is a great saving of belts, bearings, machinery and obstruction.

The practical limit of speed is in a great measure dependent upon the nature of the bearings, a subject that will be treated of in another place.

A FORMULA FOR THE BEST LENGTH OF CRANK PINS IN STEAM ENGINES.

By THERON SKEEL, C.E.*

Any rotating journal being loaded has a tendency to become hot, the work absorbed by the friction of the bearing being changed into heat. If surrounded by a non-conducting material, all of this heat would be stored up within it, and the temperature would increase until the bearing was destroyed. The tendency to become hot decreases with the friction, and any means which reduce the friction also reduce the tendency to heat. These are the use of materials for the rubbing surfaces that slide easily upon each other, aided by a good lubricant.

It is claimed by some mechanics that so long as a film of oil remains between, it matters little of what material the rubbing surfaces are.†

There is, however, a limit of pressure, beyond which the lubricant is forced from between the surfaces. This limit is probably never reached in crank-pins, and is certainly above 2000 lbs. per square inch of bearing. The bearing upon a crank-pin is less than the projected area of the pin. As an example of the limit of pressure, a mill-stone 48" in diameter, weighing, with its spindle and gear, 2600 lbs., can be run without excessive heating upon a point $1\frac{1}{4}$ " in diameter. The load per square inch of area of the point is 2600 lbs. nearly.

In computing the work of friction in a journal let—

P = load upon the journal in lbs.

d = diameter of the journal in inches.

l = length of the journal in inches.

N = number of revolutions per minute.

J = Joules' equivalent.

f = co-efficient of friction.

The work of friction in foot lbs. per minute :

$$W = P \cdot f \cdot \frac{\pi d}{12} N.$$

And the amount of heat stored up :

* Iron Age.

† A lecture delivered before the students of the Stevens Institute of Technology, by Coleman Sellers, Esq., 1872.

$$\frac{W}{J} = \frac{P}{J} \cdot f \cdot \frac{\pi d}{12} N.$$

It is probable that every unit of area of the bearing will dissipate an amount of heat depending upon its condition and independent of the whole area.

Let the number of units of heat dissipated by one square inch of surface on a crank-pin in good order = q .

Then, in order that the temperature of the pin may not increase, we have :

$$l \cdot d \cdot q = \frac{W}{J} = \frac{P}{J} \cdot f \cdot \frac{\pi d}{12} N.$$

Solving for l ,

$$l = \frac{P}{J} \cdot \frac{f}{d \cdot q} \cdot \frac{\pi d}{12} N = P \cdot N \cdot \frac{\pi f}{12 \cdot J \cdot q}.$$

$$\text{make } \frac{p f}{12 \cdot J \cdot q} = \frac{1}{K}$$

$$l = \frac{P \cdot N}{K}$$

The above formulæ were first published by Mr. Van Buren in "Strength of Iron Parts of Steam Machinery." He also pointed out that the tendency of the bearing to heat—with good lubrication—was independent of the diameter. From a number of cases in practice he deduced the value of

$$K = 350,000. \therefore l = \frac{P \cdot N}{350,000}$$

where P = area of piston \times maximum pressure less back pressure.

It is the object of this paper to determine a simpler formula for the length of the pin. As the tendency to become hot depends upon the work done by the friction, it is proportional to the mean pressure upon the pin exerted during the stroke.

Call the area of the piston = A , mean effective pressure = p' .

$$\therefore W = p' A \frac{\pi d}{12} N \cdot f.$$

Let s = stroke of piston in inch.

$$\therefore \frac{p' A \cdot 2 s \cdot N}{12 \times 33,000} = \text{indicated horse-power} = I. H. P.$$

$$\therefore p' A \cdot N = \frac{I. H. P. \times 12 \times 33,000}{2 \cdot s}.$$

substituting and reducing

$$W = \frac{I. H. P.}{2. s.} \times \frac{33,000 \times 12}{12} \pi d. f.$$

Now the amount of heat stored up is

$$\frac{W}{J}$$

and as before the amount dissipated is $l. d. q.$

$$\therefore W = l d q = \frac{I. H. P.}{2 s} \times 33,000 \times \frac{\pi. d. f.}{J}$$

$$\therefore l = \frac{I. H. P.}{s. d.} \times \frac{\pi. f.}{q} \times \frac{33,000}{J}$$

$$\text{let } \frac{\pi. f.}{q} \times \frac{33,000}{J} = \frac{100}{K'}$$

$$\text{then } l = \frac{I. H. P.}{s} \times \frac{100}{K'}$$

$$\text{or } K' = 100 \times \frac{I. H. P.}{s. l}$$

This notation differs from that used by Mr. Van Buren in that the mean pressure is used in place of the maximum pressure, and the length of the bearing in place of the length of the pin. Most of the engines in his table carried the initial pressure in the cylinder about seven per cent. less than the boiler pressure. Also they cut off at about $\frac{5}{8}$ of the stroke. Therefore the mean pressure was about 9-10 the initial pressure. Also the length of the pin exceeded the length of the bearing about 10 per cent.

Therefore, K for this notation :

$$= 350,000. \times (0.9 \times 1.1) = 350,000, \text{ nearly.}$$

From Van Buren's formula :

$$l = \frac{P' N}{32,000} = \frac{\text{mean pressure} \times N \times A}{350,000}$$

From the proposed formula,

$$l = \frac{\text{mean pressure} \times A \times N \times 2 s \times 100}{33,000 \times K' \times S \times 12}$$

Place them equal to each other and there results :

$$K' = \frac{350,000 \times 100 \times 2}{33,000 \times 12} = 177$$

This formula is particularly applicable to compound engines, for which it is difficult to determine *a priori* the pressures in the cylinders, while the horse-power can be accurately estimated from the size and proportions of the boilers ; or, in the case of a marine engine, from the figure of the ship and the proposed speed.

In this formula it must be borne in mind that l equals the length of the bearing on the pin, and not the length of the pin from face to face of cranks.

From the table of examples given below in practice there may be deduced the following: For a value of K' —more than 190—a stream of water has to be kept upon the pin. From 170 to 190 the pin will require close attention, perfect lubrication, and will be likely to heat with any neglect. From 150 to 170 ordinary care will suffice, while from 130 to 150 represents the best modern practice.

Therefore, the best value of l :

$$l = \frac{I. H. P.}{130 \times s} \text{ to } \frac{I. H. P.}{150 \times s}$$

Name of Vessel.	Line.	I H. P. (one Pin).	Length of Pin.	Length of Stroke.	Value of K' .	Remarks.
Madawasca.....	U. S. N.....	3600	30	76	158	No trouble with pin.
Spain.....	National.....	1350	19½	54	128	" "
Colon.....	P. M. S. S. Co..	800	14	42	136	" "
California.....	Anchor.....	1250	15	42	199	Uses water constantly.
Adriatic.....	White Star.....	1750	16½	60	176	
Quang-See.....	.....	600	14	42	102	
Ville du Havre,	.....	1650	16½	54	185	Requires great care.
Celtic.....	White Star.....	.....	16½	60		
Nevada.....	U. S. N.....	2240	27	48	173	Worked cool.
Florida.....	U. S. N.....	2000	27	48	155	" "
Adriatic.....	White Star.....	1500	16½	60	151	" "
Ormesby.....	.....	320	8	36	111	Gives no trouble.
Manhattan.....	U. S. Treas.....	194	6	26	124	" "
Egypt.....	National.....	1700	19½	54	162	" "

Chemistry, Physics, Technology, etc.

A NEW SYSTEM OF ENGRAVING PLATES FOR TYPOGRAPHIC PRESSES.

[A paper read before the Franklin Institute at the stated meeting, Nov., 1873,
by J. LUTHER RINGWALT]

It has become a popular entertainment in some theatres and lyceum halls for artists to draw caricatures, scenes or portraits in the presence of an audience. I propose this evening to attempt the more difficult task of having drawn and engraved in your presence a plate from which impressions can be printed, and to explain the system by which such a feat is rendered possible. The preliminary preparations consist in the coating of a zinc plate with an acid-resisting varnish, and the subsequent scoring of the coated plate with parallel incisions, so that the effect of a series of straight alternate white and black lines is produced. The artist has also traced the outlines of the picture he intends to draw. [Simultaneous with the commencement of the reading of this paper Mr. Thomas Fleming began to draw upon the plate described, the lines necessary to convert it into a picture, and subsequently an engraving of a portrait of Dr. Franklin].

The art of engraving on wood is older than the art of printing with movable types, inasmuch as block books, cut on wood, preceded the products of Gutenberg and Fust; and it is a somewhat remarkable fact that, while wood engraving received an impetus from the invention of printing, which led to its rapid development to a very advanced stage, it gradually became, from a period near the commencement of the 17th century to a time near the close of the 18th century, so much neglected and abandoned that it fell almost wholly into disuse. The works requiring illustration during this period were embellished almost exclusively by the products of the copperplate press. In the latter portion of the 18th century, however, a revival of wood engraving began. The famous Bewick was the pioneer in this movement, and he restored the art to such a high state of perfection that he had numerous successors, whose labors became better and better appreciated, and evoked a larger and larger demand as the fact became apparent that, by a proper degree of care and skill, and the employment of good art assistance, pictures capable of being printed on the typographic press could be produced of so fine a grade that, for most

practical purposes, they would answer all the ends of copperplate engraving. Copper or steel plate pictures remain the most elegant and finished of any of the black products of printing; but they are subject, from an economical standpoint, to a great disadvantage, in the slowness and costliness of the methods by which they are printed; for, while the old hand printing press, capable of turning out only a few hundred impressions per hour, has been superseded by an immense variety of machines, some of which can print twenty thousand copies an hour, and while thousands of copies of excellent wood engravings are printed per hour on various wood-cut presses, the copperplate press is scarcely more rapid in its operation to-day than it was two centuries ago, and this conjunction of circumstances goes far to account for the rapid revival and extension of wood engraving during the last eighty or ninety years, and the relative decadence of copper or steel plate engraving for popular purposes.

Desirable, however, as the products of wood engraving are, alike on account of their beauty and the rapidity and cheapness with which impressions can be taken, the art of producing them is tedious, difficult, intricate and expensive, and this fact has led to the employment of no inconsiderable amount of inventive genius in attempts to discover acceptable and economic substitutes. The motive which led to the discovery and extensive application of lithography was, if not identical with, at least akin to this incentive. The Daguerreotype and photograph had their birth in the same or a similar desire, and the Woodbury process is a still later outgrowth of the modern demand for illustration. Still, neither of these inventions exactly answered the precise object of supplying forms or plates from which pictorial representations could be multiplied with the readiness or rapidity attainable on either of dozens of typographical printing presses, and it is only during a recent period that the prospect seemed hopeful of finding substitutes for wood engraving that were in all respects entirely satisfactory.

One class of the experiments directed towards the accomplishment of this object has culminated in the discovery and application of a method for producing typographic printing plates by the aid of the photograph, and the action of light on gelatin and bichromate of potash. The products of this art, which are now becoming somewhat numerous, are good or nearly good enough for all practical purposes when the original is itself a printed picture, but the engravings produced by this method from drawings are frequently unsatisfactory



Impression from an Acid Engraving on Zinc, drawn and engraved in *Thirty Minutes* by RINGWALT PROCESS, in the Hall of the Franklin Institute, November 19th, 1873.

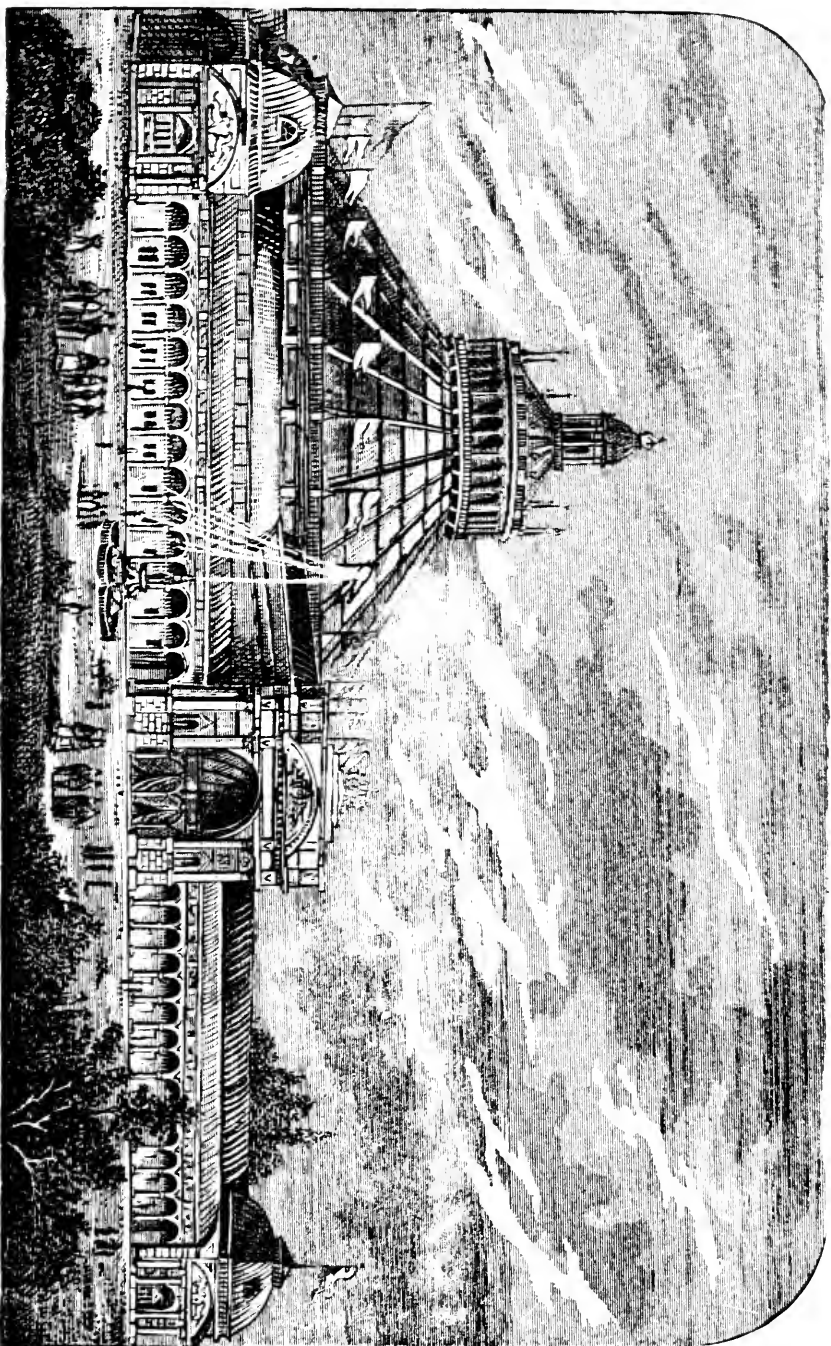
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VIENNA EXPOSITION BUILDING.—*Acid Engraving on Zinc by Ringold's Process, Patented July 1, 1873.*

unless a degree of finish, that can only be attained by long practice and great labor, has been employed in the preparation of such drawings.

Still another class of experiments, and the one to which I desire to call your special attention, is based on the employment of drawing implements, acids and tools, for the purpose of creating a raised surface on a metal plate that corresponds in its inequalities with the lines of a wood engraving. In France a great deal of attention has been paid to this system of operations during the last thirty or forty years, and M. Gillot, who died but a few months ago, brought the art of engraving with acids on zinc to such a state that it has been employed for many purposes, and resorted to with great frequency especially for illustrations of an inferior grade, which it was desirable to produce with great rapidity and cheapness.

M. Gillot demonstrated that, if a drawing is made on a piece of polished or grained zinc with a pigment or substance sufficiently powerful to protect the lines drawn from the action of acid, the whites of a picture may be eaten away, by acids, to a sufficient depth to afford the relief necessary for a typographic engraving, the acid thus doing the work of the graver; and, this principle of production being established, the details to be perfected relate to the substances to be used in drawing, the methods of applying them, and the selection and management of acids during the process of engraving.

A somewhat detailed description of the Gillot process will be found in an article published in the "Printer's Circular," of this city, for October, which I contributed to that journal, and it is therefore unnecessary to describe it more fully here.

One of the characteristics of the engravings produced by the Gillot process, which it seemed to me desirable to avoid, was their want of resemblance to wood engravings. Although printed on typographic presses, many of the specimens I have seen looked more like inferior lithographs than wood engravings. This peculiarity I believe I have fully succeeded in avoiding. [Specimens were here distributed among the audience of printed products, of various kinds, shapes and sizes, from very small pictures to posters, and some of the plates from which they were printed were also exhibited.] You may consider the pictures good, bad or indifferent, but very few persons would suppose they were produced by any other process than wood engraving; and the pictures themselves can be made as good as the art work employed in their preparation.

One of the most embarrassing difficulties involved in all attempts to produce acceptable substitutes for wood engraving arises from the great variety in the depths of the different portions of the plate or block from which impressions are to be made. It is easy enough to make all the black lines necessary to produce a printed picture; but one of the most serious tasks is to get rid of all the superfluous wood or metal that must be removed before the parts intended to be white can escape the searching touch of printer's ink. The slightest scratch on a space surrounded by the black parts of a picture will create a white mark, while indentations of considerable depth are required for all whites of considerable breadth—the general rule being that each enlargement of the area of the white portion of a picture requires a corresponding increase in the depth of the block or plate from which impressions are taken. Wood engravings are made up of a series of black and white lines, and the essential requisite in their production is the arrangement of these lines in appropriate artistic harmony, and with due regard to the effect requisite for the proper representation of the object to be illustrated. In many wood engravings the principal portion of the picture consists of a series of white and black lines or surfaces, which do not at any point possess any considerable depth or occupy any considerable area of the plate; and it occurred to me that many pictures, good enough for practical purposes, could readily be produced by creating, mechanically, on a plate a series of straight black and white lines, as the basis or substratum on which any desired design could be drawn.

This idea I have practically applied to the production of a considerable number of engravings, intended for various purposes, and impressions from these engravings have been taken on all the leading varieties of typographic presses. I have also patented this principle or process of production, as will be seen from the following extracts from the specifications of a patent granted to me by the United States Patent Office in July last, viz. :

The object of my invention is to produce quickly and at a cheap rate plates from which pictures may be made by an ordinary typographic printing press, and this object I attain by drawing on a varnished and scored plate, with acid-resisting varnish, the picture to be produced, and then subjecting the plate to the action of appropriate acid.

In carrying out my invention, the first thing to be done is to select a metal plate of proper size, having a perfectly plane and smooth surface. I prefer, both on the score of economy and efficiency, ordinary sheet zinc. I first cover the plate with a thin coat of varnish, or other material capable of

resisting the corrosive action of the acid to which it has to be subsequently subjected. I then, by means of a ruling machine, score the entire surface of the plate. * * The varnished surface of the plate may be scored with any system of lines which the character of the picture to be produced may suggest, the scoring determining the style of groundwork of the picture. After the varnished plate has been thus scored it is ready for the artist, who proceeds to paint with a resistant varnish on the scored surface the design or figure he desires to produce. * * At the points where high lights are required the varnish is scraped away and the metal surface of the plate exposed to an extent and form determined by the character of the lights. The plate is now subjected to the action of dilute nitric or sulphuric acid, or other corroding bath usually employed in etching, the acid eating away all the parts of the metal exposed. When this process has been completed, the varnish is removed from the face of the plate, and the latter is then mounted on a block of appropriate thickness, and this block may be used for printing from in an ordinary typographical press, the ink adhering to those parts only of the plate which had been covered with the varnish. The impression taken from the plate will consequently be precisely like the varnished portion of the same. * * More elaborate plates may be produced by varying the character of the scoring in a manner which the nature of the picture to be produced may suggest.

The operation now in progress is based on these ideas. [Reference was here made to the drawing which Mr. Fleming was about completing, and a few minutes later he immersed it in an acid bath.] A zinc plate is covered with a varnish capable of resisting the action of acid. Through this varnish a series of lines are drawn at regular intervals, thus opening up avenues in which the acid can make the desired incisions; and the shape, thickness, position and direction of these lines or scorings can be varied so readily that the basis of pictures of any desired grade of fineness can easily be established. If the plate was subjected to the action of acid immediately after the completion of this operation, impressions from it would present a mere alternation of straight white and black lines, of a width corresponding to the width of the incisions and the length of the time the plate was exposed to the action of acid of a given strength, or to the strength of the acid applied: for it is worthy of remark that a great variety of shadings and effects can be produced from a given ruling by the variation of the strength of the acids applied, or the variation of the time during which the plate is subjected to the action of acid of a given strength.

After a plate has been covered with a protecting varnish, and scored in an appropriate manner, the artist in his drawing creates additional blacks by applying a protecting liquid with a pen or brush at the points where additional blacks are required, and removes with an etch-

point or scraper the original protecting ground from the places where additional whites are necessary. This operation finished, the plate is next subjected to the action of dilute acid, and during this process a variety of beautiful effects can be produced by stopping out or covering with a protecting varnish different portions of the picture at various stages.

This resource supplies a very fair substitute for the varied shadings of an India ink drawing.

By these simple methods I conceive it to be possible to represent almost any desired object; while, by a resort to the analogous process of Gillotage proper, a variety of broad and deep whites can be obtained, when they are necessary; or, if Gillotage fails, mechanical processes can be employed for the removal of the metal from places where broad and deep white areas are required.

All young arts necessarily encounter many minor difficulties and obstacles, which can only be fully surmounted by devices discovered or suggested during a protracted experience. They do not suddenly spring into existence, fully equipped at all points; but, when they are based on correct principles and calculated to supply a popular demand, they gradually attain a perfect development.

That acid engraving on zinc, for the production of typographic plates, will reach this point, I firmly believe; and the extensive application of such an art, not merely at a few great commercial centres, but in hundreds or even thousands of printing offices scattered throughout the world, would lead to the illustration of thousands of objects of business or literary importance, from machines, houses, animals, furniture, the varied manufactures described in business catalogues, and men, to events and localities, of which no adequate description is now given; and thus the movements and things of the age would be faithfully portrayed for present instruction and the enlightenment of all coming generations.

[At the conclusion of the reading of this paper, which occupied about thirty minutes, the drawing and engraving of the plate referred to was completed, and in a few minutes later a rough proof, beaten off with a planer, was handed round among the audience. A more finished impression of the same plate accompanies this article.]

DESCRIPTIVE GEOMETRY MODELS.

BY S. EDWARD WARREN, Mass. Inst. of Technology.

Being not very unfrequently consulted by letter relative to the varieties of models used in illustrating Descriptive Geometry, and the way to procure them, I have thought that a few notes on the subject might be interesting to many of the readers of this Journal.

Descriptive geometry models may be classified superficially according to the materials of which they are composed; or, more rationally, according to the kind and amount of aid and study which they are capable of affording.

According to the first basis, such models may be described as wood, tin and wire models; plaster models; and string models.

According to the second basis, models may be designed, *first*, merely to give an idea of forms unfamiliar in common life, with such of their elementary properties as are obvious on a little reflection by inspection of those forms; for example, any popular audience would understand what was meant by a pyramid, a cylinder, a cone, or a sphere; but at the mention of a hyperboloid, conoid or helicoid, there would probably be a nearly unanimous look of wonder, and a felt demand for a model: *second*, models may be designed to add to this an exhibition of the *results* of certain combinations of forms, as the intersection of two cylinders; and, *third*, they may illustrate the means of obtaining these results, point by point, and either, *1st, in space*, or, *2d, in projection*, or, *3d, in both*.

From this general view of the subject, we may now proceed to a more particular account.

I know of no models which illustrate, both in space and in projection, the *operations of the solutions* of problems; such, for example, as finding the intersection of a line and a plane, or of two solids, and others of analogous character; except a few, made partly by myself, and partly by workmen under my direction, for my former classes at the Rensselaer Polytechnic Institute, at Troy, and which, so far as made at the expense of that institution, are presumed to be there still.

The nearest approach to this essential completeness in any models manufactured for sale, so far as I know, is in the Schröder models, made at Darmstadt, in Germany. These show lines by stout brass wires; planes of tin, painted white; and solids, of pear wood, dowed with brass pins when necessary, in case of combinations of solids.

Here it may be said in passing, that the brass pins by which models are often dowelled together, are usually too short or slender, so that the model tumbles apart at a touch in arranging it. By making them of one eighth to one quarter inch wire, or rod, tightly fitted, this difficulty is obviated, and the model is more readily put together. The Schröder models further show the projections of forms on wooden planes of projection in their real positions at right angles to each other, and covered with varnished paper, on which the projections are engraved. But they do not show the auxiliary lines and planes in space, which are employed in finding the required results, such as lines of intersection, of bodies combined in given ways; and in this respect they fail, like all other models, at the very point where learners most need help. Still, they are very useful, and by far the most serviceable that I know of, in that they leave less to be imagined than any others do.

Illustrated price lists of Schröder's models, illustrative of every art, can be had through any of the German, or other importing booksellers.

PLASTER MODELS, designed by Bardin, in Paris, simply show intersecting pairs of bodies; showing clearly the finished result in space, of their penetration, and so far showing the reality, which is found in projection by graphical construction, and thence imagined in space with more or less difficulty. But they exhibit neither the reality, nor the projections, of the means for obtaining these results; so that the lecturer is strongly tempted to draw pencil lines upon them, to assist in conceiving of the methods of finding their curves of intersection. Such models are made in Paris by Muret, and by Les Freres, Rue Oudinot, and lists would doubtless be found at French and German book importers.

STRING MODELS are of two kinds. The first are fixed string models, each of which simply shows some one example of some unfamiliar surface, generally a warped surface. The second are the celebrated Olivier models, in which the strings are kept stretched by little weights attached to each, and concealed in boxes on which the model stands, and through the top of which the strings pass. This curious construction is because the models are transformable, so as to show various forms of the same surface, by shifting the perforated brass bars or rings to which the strings are fastened. The depth of the boxes which conceal the weights is nicely adjusted to the extreme range of motion of the weights, occasioned by shifting the supports of the strings.

The late Prof. Gillespie informed me some years ago, that there were then but three sets of these models in existence, of which his own, then and probably now at Union College, Schenectady, was the fullest and most complete.

These models are too costly for most institutions, and too complex except for advanced students, who might spend days upon each or many of them in unravelling all that the model could teach. But a few fixed string models of warped surfaces, and of intersecting cylinders or cones are very useful, and can easily be made by any one, with a little aid from an instrument maker, or a cabinet maker, in making the wood or metal supports of the strings.

Indeed, it is by no means the highest mechanical finish that makes a model most useful; and when mechanical laboratories become as common as chemical ones, as they ought to be, and when *thoroughness* shall replace *haste* among the national deities, nothing could be more admirable than to spend a school year on Descriptive Geometry (other work duly included), and require each student, as a part of his work in the mechanical laboratory to make and present a card-board model of every problem which he should draw. But this result touches another question, viz: that of expending five years in doing the work which is now crowded into the existing American four-year courses of scientific instruction; and by means of a general course of three years, preparatory to a purely professional one of two years; the two being under one management, or in allied institutions.

Nearly connected with models, and yet not quite entitled to the name, are pictures of models, or picture models, that is, isometric, or oblique projections of real models. These, by representing in dotted lines important parts, which the *opaque materials of real models often conceal*, are often better than the models themselves.

No model, for instance, could show *more* clearly than such figures do, the point of intersection of a line with a plane, and how to find it; or the conditions under which two cylinders, etc., will intersect in one curve, or in two separate curves; together with the turning points of the curve and its relations thereat to the elements of the given surfaces.

To conclude with a suggestion: it would be doing excellent service to technical education, to establish in this country the manufacture of models possessing the completeness of design which I have indicated as not yet attained; and accompanied by charts of corresponding pictorial views of the same.

SANITARY CARE AND UTILIZATION OF REFUSE OF CITIES.

(A paper read before the American Public Health Association, Nov. 12, 1873.)

BY JACOB J. STORER.

That the conclusions I have arrived at respecting the proper treatment of animal refuse may be better comprehended, it is necessary that a brief description be given of the most advanced methods now practiced.

From most of the packing and slaughtering houses the blood from the slaughtered animals flows into receiving tanks, whence it is gradually removed to different places to be manipulated for its albumen, or dried for a fertilizer, or some other purpose. In summer the heat causes the blood in these receiving tanks to become offensive in a few hours. Hence the first cause of complaint.

I would recommend that such tanks be made double, the inner one of iron and the outer of wood, and that a space of from six to eight inches be left between the two, which shall be kept filled with ice or shall have cold water constantly flowing through it. This should keep the blood at a temperature at which decomposition and consequent offense would be prevented.

In some cities the blood and much of the offal flows directly into the sewers. Where there is a plentiful supply of water and the sewer mouths are far enough off, or emptying into a rapid current, there may be but little objection to this plan as far as the city adopting it is concerned, but towns and neighborhoods along the course of the river, below the sewer mouths, as shown by statistics throughout Europe and this country, suffer to a great degree. To allow this, then, cannot be a good sanitary measure.

The great need of the times is that an economical system be devised, and everywhere adopted and carried into effect, by which the tank steam, blood and tank offal, &c. of packing, slaughtering and rendering houses shall be disposed of without violating the laws of health.

Boiling and Fat-Melting Establishments.—The steam and gases from the tanks in which solid animal matter is boiled or steamed, for the purpose of extracting the grease, are perhaps the greatest causes of the offense appertaining to these establishments.

The usual method of conducting the steam and gases through cold iron coils for partial condensation, and making the uncondensed portion pass up through the fires under the boilers, is in most cases ineffectual, for the reason that the boiler fires are rarely, if ever, of

sufficient capacity or intensity to decompose and burn all the steam and gases, while that portion of them passing undecomposed or unburned through the coils has its temperature immediately reduced by contact with the heat-absorbing surface of the boiler and escapes with its bad odor into the air.

Where this method is in use the exceedingly offensive condensed steam is generally permitted to flow into the sewers or water-courses, to the detriment of health.

Conducting the steam and gases through heated tubes and then into a good fire is complete and effectual, provided their volume is not in excess of the effective power of the apparatus.

Another plan recently brought into notice is to pass the steam and gases through cold coils, allowing the condensed portion to run into the sewers, while the uncondensed portion is passed through vessels containing lime, for the removal of some of the stench, and thence over naphtha, benzine or gasoline, for the absorption of carbon, and then is burned as illuminating gas or carried under the boilers to generate steam.

A portion of the offensive odor in this case is transferred into and concentrated (not destroyed) by the lime, while the rest is rendered inoffensive by burning.

As the uncondensed steam and gases can be properly disposed of without the intervention of lime or liquid hydro-carbons, it is not easy to discover any advantage in their use.

By another method, recently introduced, the steam and gases are blown off into a closed tank, and there condensed to a good degree by copious sprays of water holding in solution sulphate of iron and chloride of lime.

The uncondensed portion, still offensive, is conducted under the boiler fires. The condensed portion is inoffensive, and no objection can be made to its flow into the sewers.

The filtering of the condensed steam through charcoal or other substances for the purpose of deodorizing it, while the uncondensed is burned, is another method.

There are several other devices, approaching, as these do, the solution of the problem; but it will be seen that no matter what condensation or purification takes place, a large portion still remain uncondensed and offensive and has to be disposed of.

The Most Effectual Scheme.—The plan I find most effectual and economical is to build a combustion chamber or oven with a deep ash-

pit, made water-tight with cement. The roof of this chamber is full of small openings made by leaving 2" or 3" spaces between the ends of the bricks. An oven or chamber four feet square, with a roof four or five feet above the grate, will suffice for any packing house, if the tanks are blown off successively—no two at the same time, no matter how large the escape pipe.

The steam and gases are then blown off through a cold coil; the condensed steam runs into the ash-pit basin, where it is gradually evaporated and, passing up, is burned by the fire above; the uncondensed steam passes directly up through the fires.

A slight blast keeps the oven always at a white heat, the roof detains the gases and steam until they are thoroughly decomposed and burned, and at the same time serves to concentrate the heat in the oven.

The escaping flame may be utilized for generating steam, heating furnaces or any other economical purpose. The apparatus is simple and the result is perfect, no offensive odor escaping.

The Disposal of Offal.—The next point for consideration is the care of the tank offal.

A beeve gives 50 lbs., a hog 20 lbs., and a sheep 7 lbs. of this.

In some instances this is thrown into the water-courses, in some upon the surface of the ground, or buried in trenches to be gotten rid of. It is even permitted by the health authorities in some places to accumulate during the winter, when it gives but little or no offense, and be gradually worked up into a fertilizer during that season, while the excess is allowed to remain in decomposing and stinking heaps throughout the next summer until the return of cold weather, when the fertilizer manufacturer gets again at work.

Public health demands that this offal shall not accumulate anywhere, and that the disposal shall be inoffensive, thorough and immediate. The same demand is made respecting the dead animals of the cities, and those dying in transit on their way to them.

Public economy—the agricultural interests—requires the utilization of this material.

My attention was first called to this subject about a year ago, and though it was entirely outside of my legitimate business I became interested enough to investigate the matter in all its details of defects and needs, and have made extensive and practical experiments and observations for the purpose of discovering a proper system of manipulation.

The importance of the results obtained must be my apology for alluding to the method I have designed and practised.

Of the treatment of the tank steam and gases I have already spoken.

I found that the various offal driers in use were slow in action and offensive in operation. That it was most desirable for sanitary reasons that the blood and offal should be dried and rendered inoffensive immediately on their production; that no accumulation of them should be permitted, and that, consequently, for places where much packing is done and for all large cities, driers should be designed and operated of much greater capacity than any then in use.

One Scheme carried out in Chicago.—I designed and erected at the Union Stock Yards, adjoining Chicago, a brick-lined cylinder 20 feet long and three feet internal diameter, having at one end a fire-place and at the other a smoke-stack.

The intense flame of burning pulverized fuel is injected directly into the cylinder, which has a capacity to treat four tons an hour of mixed blood and tank offal. The jet of flame is not only intense but is constant, so that the drying of the material in the cylinder is very rapid.

In the base of the smoke-stack is a gas combustion chamber of the style and dimensions spoken of in the first part of this paper, and a hot fire is constantly maintained therein.

The offensive steam and gases escaping from the cylinder when in operation, pass into this combustion chamber, and are there decomposed and burned so completely that no offensive odors escape; while the resulting flame often extends 20 feet up the stack, bringing its fire-brick lining to a white heat. This flame is sufficient to generate all the steam required to run the machinery of the works. That its results were most satisfactory may be judged from the fact that the Trustees of the town of Lake, wherein the works are erected, closed all the other offal-drying establishments within their jurisdiction early in the summer, because of the offense they created, but urged that my works should be kept in operation. At the close of the past summer they unanimously passed a series of resolutions thanking me for having conducted the works without creating any offense whatever, and declaring that for years they had not had a season so free from nuisances, and requesting me to increase the capacity of the works in order that the town might be further freed from foul odors and the accumulation of animal refuse.

Dr. Miller, the Sanitary Superintendent, and Dr. Reid, the Health Officer of Chicago, have often visited my works and fully endorse the expressed opinions of the town of Lake authorities.

Encouraged by this action of the authorities, I have arranged to have in operation there in a few weeks another cylinder capable of drying 10 tons of raw blood and tank offal an hour. The machine is 50 feet long by 5 feet in diameter.

A jet of pulverized fuel, constantly burning in the gas combustion chamber in the base of the stack, will insure thorough decomposition and burning of all the offensive gases and steam which must so rapidly escape during the treatment of this large amount of material.

From various causes, lack of co-operation, etc., I have not been able to carry my system into practice in all its details.

Still Another Plan.—A further step in this system is the treatment of the tank water or soup.

It is estimated that there are about twelve gallons of tank water, or soup, made per beeve, three gallons per hog, and one gallon per sheep; according to these estimates, there is annually produced in Chicago, and permitted to run into the water courses and sewers, about 8,000,000 gallons, or 36,000 tons.

It is easy with these figures to arrive at the amount produced in other cities.

This 36,000 tons of tank-water carries with it to the river not less than 4,000 tons of animal matter in solution, or suspension, after the heaviest particles of matter have been deposited in catch basins.

Some obtained near Boston, and filtered through a charcoal filter, still retained in solution eight per cent. of animal matter in the form of glue. This is exceptional; as a general thing, I think, the animal matter is of such a character as to be easily removed by proper filtration. Many persons have attempted to solve the problem how to separate the animal matter from the liquid, so that only clear water should flow into the sewers.

It appears to me the best plan in most cases would be to run the liquid, as is now usually done, into catch basins, where the heavier particles of the solid matter will settle, thence into a second series of basins, where still another considerable portion shall be precipitated by chemicals. The soup, now partially cleared, carrying say from five to eight per cent. of solid matter in solution, should be made to flow from the precipitating basins and be submitted to the downward

intermittent filtration process, through earth, which has been so successfully adopted for the treatment of the sewage in some towns in England.

I think the adoption of this plan would insure the flow of clear water into the sewers.

In the choice of precipitants to be used in the second series of tanks or basins we should be guided, I think, not only by a desire to obtain an effective precipitate, but also by the cost of the material and the value of the resultant. I suggest that milk of lime be first thoroughly stirred in with the liquid, and that then sulphuric acid be added.

This treatment causes a quicker and more complete precipitation than any I have tried, the resultant contains nothing not of value as a fertilizer, while the cost of the chemicals is fully recovered in the value of the material.

This process is not adapted to the treatment of tank-water containing a considerable amount of animal matter in the form of glue. A proper treatment in such case has, I am assured by Mr. B. F. Shaw of Cambridge, Mass., just been discovered by him and is about being applied at the works of the Boynton Packing Company. He claims to remove all the glue in solution, leaving the water odorless and almost colorless, and that the result of the animal matter removed more than covers the cost of the manipulation.

Pork Packing and Slaughtering Houses.—There is still another point of importance that has received but little attention and which yet is a matter of serious offense from hog packing and slaughtering houses.

From three-fourths of a pound to a pound of blood, bristles and dirt is deposited in the scalding vat by each hog scalded. Invariably, I believe, this water with its burden of animal matter is permitted to flow into the sewers. In the presence of so many and great causes of offense this one has been generally overlooked, yet it requires consideration.

Mr. Shaw designed and has in operation, at the establishment of the Packing Company above spoken of, a successful method of treating this matter which I will briefly describe:—

The water for scalding is generally kept at a temperature of about 145° Fahrenheit. When it has become foul and offensive from use he mixes with it some charcoal dust and allows it to cool down to about 90° Fahrenheit. This is done between the hours of slaughtering. To

hasten the cooling, ice may be used. When the water is cooled sufficiently a quantity of blood, and sometimes a small amount of sulphuric acid, is thoroughly stirred into it, and, after the mass is well mixed, the temperature is raised to the boiling point for a few minutes.

The coagulum caused by this means encloses the charcoal and the impurities that were suspended in the water, when they are removed by a skimmer of netted wire.

The water is thus made pure and sweet enough for use again, and may be cleaned and used several times successively.

Mr. Shaw suggests that the scrapings and wash water of these establishments may be collected in vats supplied with steam-heating pipe, and manipulated in the same manner.

It is possible in this way to prevent wholly the escape of blood, manure and scrapings from the drains of slaughtering establishments. The material recovered from these scalding vats is valuable as a fertilizer, and more than reimburses the cost of the operation.

In most instances the packing, slaughtering and rendering establishments are *scattered* throughout our cities, each one offending a very considerable neighborhood, jeopardizing its health and depreciating the value of the land and houses thereabouts.

Few of the establishments can afford to erect works for drying their offal and blood, or adopt proper means for the care of the tank water, &c. Those who can afford to do so, do not care to add to their other business that of manufacturing fertilizers.

A Good Suggestion.—The removal of these establishments to one location would result in very great pecuniary as well as sanitary advantages to the neighborhood from which they move; while their assemblage at one place would make it easy for them to adopt a system of management that would satisfy all sanitary conditions. At this place, wherever it might be, one establishment could be erected which should treat all the blood, offal and tank water each hour of its production. The blood and offal could be hauled to the drying works in covered carts, all offense being prevented by dusting the interior of the carts with powdered charcoal, and covering the tops of their contents with the same, while the tank water could be conducted by sewers into one common reservoir for treatment.

Glue and Bone Works.—Prominent among the nuisances to be found at glue works, is that arising from the heaps of skulls, bones, hoofs and horns, generally piled in the open air till the flesh is re-

moved from them by gradual decomposition. From these arise constantly the most offensive odors. I know from practice a simple and effectual remedy for this nuisance.

Enclose a common house furnace in a brick chamber, the cover or top of this chamber to be made of iron gratings, or perforated plates; on this is built a strong wooden bin with a roof, in which shall be an opening, say two feet in diameter. A fan blower is placed near the top of the bin, having both a suction and force pipe. This bin is filled with these skulls, etc., and fire made in the furnace, the suction pipe attached to the opening in the top of the bin, and the fan put in motion. The heated air is drawn up through the contents of the bin, and with its burden of moisture and offensive gases, is ejected through the force pipe into the fire. A few hours of this treatment is more effectual than weeks by the present offensive method. The *expense* of establishing new methods has been the principal cause of hesitation on the part of health departments, in enforcing practical improvements.

Considering that the element of time enters largely into all practical values, I have endeavored to show the economy of a rapid and thorough system of manipulation of the animal refuse of cities.

GRAMME'S MAGNETO-ELECTRIC MACHINE FOR CONTINUOUS CURRENTS.

Translated from the French by Alfred Niandet-Breguet.

The induction currents present themselves more frequently with the double character of being instantaneous and of being alternately of opposite character. Many are of the opinion that these induction currents cannot be produced without these two conditions. This is a great error, for it may be said that none of the phenomena in nature are instantaneous in the proper sense of the word, and in each particular case it could be shown that the time of these induction currents may be estimated. If we consider, for instance, the machine of Pixii (called Clarke), we see that the production of the current in each bobbin lasts as long as the motion of this bobbin between the north and the south pole of the magnet, and the duration of this motion may vary considerably and become very great. If the machine is made to move slowly, the current continues sensible to the galvanometer. As to the possibility of obtaining continuous induction currents, that is to say of an indefinite duration, it has been shown

by Faraday himself, in his first essay on induction, of November, 1831, that they are producible. He caused a plate of copper to revolve around its centre, the edges of which passed between the two poles of a magnet, and by means of a galvanometer he perceived the passage of a current from the centre of the plate to the point between the two poles and the magnet.

Thus, said Faraday, (page 27, Vol. 1, "Experimental Researches,") was demonstrated the production of a permanent current of electricity by ordinary magnets. This beautiful experiment figures in all the English elementary works. Unfortunately it is very little known in France, at least under this form, from which has resulted the error which we have pointed out in the beginning, and which is so prevalent in France.

It is important to notice, beside, that if this fine experiment of Faraday's has not received practical application, it is for the reason that the production of electricity by this process is not susceptible of multiplication.

The problem of the production of the electricity of induction in

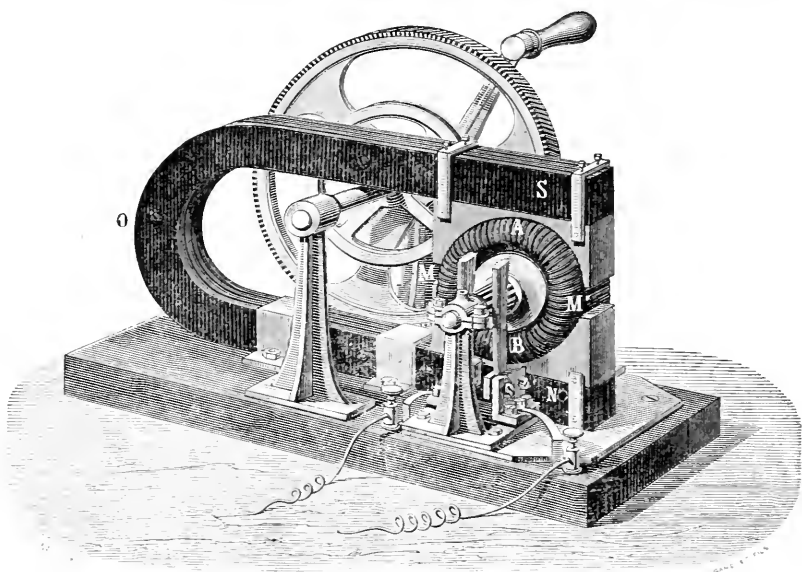


Fig. 1.

abundance may therefore be reasonably assumed. It appears that Sir Charles Wheatstone had found the solution of this problem, and that he had neglected to publish it because he found it not very prac-

tical. Things were in this state when Mr. Gramme made known in July, 1871, to the Academy of Sciences, a machine that completely solved the problem, for which he took out a patent in 1869.

Gramme's machine (Fig. 1), is composed of a magnet, between the poles of which revolves an electro-magnet of a new form that requires a minute description. This electro-magnet is formed of a ring of soft iron, over which is wound a conducting wire, presenting no break in continuity, so that we may consider it formed by an ordinary electro-magnet curved into a circle; the two ends of the wire being so soldered to each other to establish continuity. This piece may

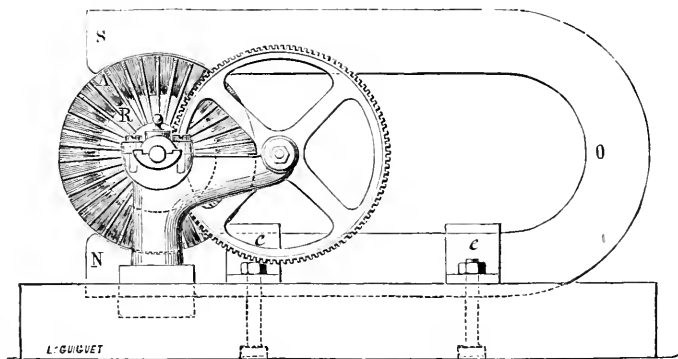


Fig. 2.

be considered as an endless electro-magnet, since the soft iron and the conducting wire are absolutely continuous. It constitutes the first part of the invention of Mr. Gramme. In Fig. 3, the electro-magnet

is represented in section at A, and in the other figures it is seen with the wire with which it is covered; it is movable around its centre on an axis, to which movement is given by means of a pinion and a cog-wheel M, or other device (Fig. 1 and 2). Let us now see how the current is produced in the wire of the endless magnet. This wire we have said is without break of continuity, but it is arranged in sections, each composed of about a hundred revolutions. The end of the last

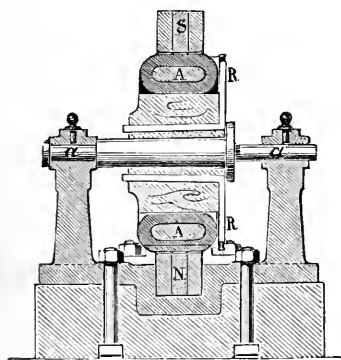


Fig. 3.

revolution of one of the elements in question, is the commence-

ment of the first revolution of the following element ; altogether the wire is therefore divided in forty sections, all equal and forming a continuous pole. We must examine experimentally the production of the current in one of the sections or elements, and for this purpose we attach its two ends to two wires connected with the galvanometer. We start from the line (which we call the line of distribution) perpendicularly to the line of the poles, and we give to the considered element a series of movements of 10° each, at the end of each of which we give time to the needle of the galvanometer to retake its position of rest.

We see that during all this time the said element remains above the plane of distribution, the direction of the motion remaining the same. The currents that are there produced in it are in the same direction, which we will call positive, that when afterwards the said element passes below the plane of this distribution. The currents which are then produced are in the direction which we will call negative, and which is contrary to that of the first half of the circle. We may also prove in this experiment that the change in the direction of the motion causes the change in the nature of the current. From that instant, we can, by the knowledge procured from one of these elements, come to the general phenomena produced by the whole machine. All the elements that are above the plane of distribution are the points of the currents, which are at all times of positive sense. They can be unequalled between themselves but for the same velocity of movement their sum is evidently always the same, for, as one of these elements passes above or below the plane of distribution, it is replaced by another. Again, the elements above the plane of distribution are the points of the negative currents ; the sum is constant and equal to that of the currents of the superior part. Thus the machine, reduced to the parts that we have already described, presents two systems of elements producing unequal and contrary currents, or, in other words, two opposed currents ; that is to say, they are neutralized. This system can be better understood if formed by two Daniell's batteries of 20 cells each, put in opposition by poles of the same name. We now come to the method employed for collecting these currents, which method is similar to the one we have already used. To collect the currents of the two batteries in opposition it suffices, as we already know, to put the two ends of the circuit in contact with the points of reunion of similar poles. The batteries having been placed in opposition, the currents which before were neutralized, and the circuit closed,

we will have our currents in any quantity. We will here show that this is the same as Gramme's method, and that this manipulation constitutes the second part of his invention. The different sections of the endless electro-magnet are connected by radiating metallic plates R, made of copper, (Fig. 2 and 3), which, being placed close together, are yet properly insulated. The finishing end of one section and commencing end of another are connected to one of the metallic radiating plates R, which must consequently be of the same number as the sections. It is seen that R has a radiating form (Fig. 2 and 3), but it is, for convenience, bent near the centre, at right angles, and being insulated one from the other, they appear like a concentric circle to the ring, and on the opposite face. Two rubbers not shown, presenting the form of discs of brass, bear against the circle formed by the extremities of the pieces R, at two points that are exactly in the plane of distribution, that is to say, at the place where the equal currents of opposite natures produced in the two halves of the ring oppose one another. Consequently the two currents commence to proceed together along the exterior circuit that is made to bear on the rubbers. The absolute continuity of the current obtained in this way results from the rubbers rubbing at the same time on many of the pieces R, the result of which is that the metallic circuit is never broken. The effects obtained by the means of these machines are changeable by the speed which we give the ring of the electro-magnet.

The electro-motive force is as much greater as the number of coils of wire wound around the ring, but the relation between these two quantities has not yet been determined. It will afford a subject of interesting investigations. The theoretical resistance of the machine ought to be the fourth part of the total resistance of the wire wound around the ring ; but little attention is needed to account for this. But the real resistance is smaller because each rubber bears always on many junction pieces, R, of the elements, and that the resistance of the elements thus pressed by the rubbers is diminished by the resistance of the circuit. For obtaining electric force more and more intense, machines of Gramme may be put together as elements of batteries are put together, whether for tension or for quantity. As to the possibility of obtaining greater effects by augmenting the dimensions of the machine, it is too evident to stop and consider. By means of this machine we may perform all the experiments that are made with batteries, chemical decompositions, heating of fine wires, putting in action

electro-dynamic apparatus or electro-magnets, electric lights, etc. Hence there is reason to expect that it will be applied in a short time outside of the physical laboratories, properly speaking: 1st, in medicine, to furnish continuous and discontinuous currents. 2d, in electric telegraphing. 3d, in galvanizing, for gilding with silver and gold. 4th, in electric lighting. 5th, in the military art for the explosions of mines. 6th, in chemical decompositions, etc.

General Advantages.—We have now to examine the interest that presents itself in the application of the machine, and to find in a general manner what advantages it presents over the battery. Before all, we must note the absolute constancy of the currents furnished by the machine as long as the speed does not change; this constancy has been preserved for eight hours in an experiment made with one of the first machines that were constructed, maintained at a uniform motion by a Fontane motor. During this duration, the deviation of the needle of a galvanometer was strictly invariable. That understood, persons who have handled the Daniel battery, (which is by far the more constant of all batteries) know that if the electromotive force did not vary, so to speak, its resistance varies constantly, so much that in two experiments made in the interval of a minute, we would not have exactly the same intensity. A battery is a very complicated machine, for each one of its elements is composed of four solid and distinct parts, viz: outside vessel, porous cup, electrode positive, electrode negative, and of two liquids, and in the greater number of applications we are obliged to employ a sufficiently large number of elements. The results of this multiplicity of parts that compose a battery, that it is subject to many derangements, the simplest of which, the breaking of one of the glass vessels, is sufficient to stop entirely the production of the current. To the complication of the battery it is interesting to oppose the simplicity of Gramme's machine, which requires hardly any care. It is very remarkable that batteries are, with very few exceptions, horses at livery, that is to say that they cost as much at rest as when they are used. Gramme's machine, on the contrary, costs nothing when it does not furnish any current. This may be understood in two ways. It is at first evident that we may stop the rotation of the machine when we do not need a current, but it is very remarkable that, even in the case when it turns, it does not waste any mechanical force if it does not furnish a current in an exterior circuit, (allowance being made for the force destroyed by the friction of two trunions and of bearing springs). There is need

to stop for a moment at the second point in order to establish it in an incontestible manner. If one considers Gramme's machine in rapid motion, and furnishing in an exterior circuit on the condition always that the exterior resistance may be equal or greater than the interior resistance, we prove that it does not become warm. From which we may conclude that all the mechanical force transmitted to the machine is converted in electricity, for no portion of it is converted into heat. If the machine, continuing to turn with the same velocity, has its exterior circuit broken, it is still shown that the machine does not become heated, which shows that in this case there is production of neither heat nor electricity, and consequently that there is no waste of mechanical force, and we may even notice that the production of the currents is such in this machine, that when there is no exterior circuit to set them flowing they compensate and balance one another so exactly, that they do not circulate in any way, since they do not heat their own circuit. If Gramme's machine is put in motion by a force just sufficient to make it turn at a determined velocity, when it furnishes an exterior current, and if we break the circuit off all at once, we see the machine immediately take an increasing velocity, the mechanical force which is transmitted to it not being able any longer to transform itself into electricity, is transformed in mechanical force by augmenting the velocity of the movable pieces of the apparatus. Reciprocally, if Gramme's machine is maintained in a sufficiently rapid motion while the circuit is open at the moment in which we close the circuit, we see the velocity of rotation diminish; that is to say, that a portion of the mechanical force of the machine, and of the fly wheel that may be attached to it, is converted into electricity. In these reciprocal experiments we pass from a first to a second state of equilibrium between the expenditure of mechanical force and the production of electricity. In conclusion, we may say that Gramme's machine is an apparatus very nearly perfect, for the transformation of mechanical force into electricity, or in other terms, that this machine does not expend any more than it produces. With these remarkable advantages of the Gramme machine, it is important to note the saving of time in preparing electrical experiments for the laboratory. The getting up of a Bunsen battery is an operation not only very expensive but very long. This we must hesitate in getting up, if we have not before us several hours of labor. On the contrary, the Gramme machine is always ready, and permits the repeating of an experiment that was left in series of experiments

from one minute to another, or to make a grand demonstration of a known phenomena. From this point of view it would be interesting to construct the machine equal to 10 or 12 Bunsen elements, by means of which we could repeat the greater part of the new experiments in the instruction of physics.

Experiments in electro-dynamics, electro-magnetism, electro-chemistry, etc., the various studies made with the induction coil, called Ruhmkorff, can be facilitated by means of Gramme's machine, which dispenses with acids and the cleaning of batteries.

We again call attention to the general accessory advantages of this machine over the battery; the acid vapors and the inconvenience resulting therefrom, the danger of manipulation and of poisonous substances, by careless assistants, the injury which may often accompany the manipulation of liquids, and the trouble of keeping up constant batteries, are altogether avoided. An objection can be put forth that this machine always requires an assistant to put it into motion, and that this motion cannot be indefinitely continued. This difficulty is not as great as it appears to be; that is to say, we can very often turn the machine and use it at the same time. It can be turned by hand or by foot, in the same manner as the sewing machine, which latter leaves the two hands free. If, then, one has need to put off the experiment for a long time, or to be at liberty altogether, he can employ any motor whatever.

This will be for the industries an ordinary steam engine; for the laboratory, or the telegraphic bureau, a domestic motor.

ON THE MANUFACTURE OF TIN PLATE.

A paper read before the Franklin Institute of Philadelphia, on the evening of October 15th, by Thomas S. Speakman, Esq., representative of the Institute at the Vienna Exposition, gives the following interesting details of the manufacture of tin-plate as carried on in Wales:

In the opinion of Mr. Henry I. Madge, tin-plate manufacturer, of Swansea, in Wales, from whom I received the following information, the manufacturer prefers making his own iron to purchasing it, because he can thereby insure a more regularly equable quality; he therefore buys suitable pig-iron.

For common coke tin-plates, the "iron bars" are made from puddled iron. The puddled ball is sometimes squeezed and sometimes

hammered ; much depends on the care of the puddler to so bring forward his ball that all its parts shall be equally decarbonized, when the fracture will be of a uniform dull gray color, without crude admixtures of bright crystals. The unreduced crystals produce more or less wasters of the iron plates, and if any such escape the notice of the mill manager, the wasters are thrown aside again, after being expensively covered with tin. If they escape the eye of the "assorter," the tin-plate worker will find them to fracture across the angles or bends of the sheets in working them up. The puddled ball produced under the best conditions is then taken to the "shingler," who submits it to the squeezer or hammer, sometimes both. This operation should be carefully executed. As the puddled ball is rugged and full of cinder, the cinder has to be well squeezed out by this operation, and at the same time the roughness must be so managed as to be welded into a solid compact mass, which cannot be so well done in after operations. Some say it cannot be done afterwards, as the whole mass can never again be brought up to a thorough welding heat throughout, unless at the expense of much waste and loss. The bloom from the "shingler" is at once passed through the rolls, or roughed down into No. 1 bar ; some prefer letting the blooms lie exposed to the action of the elements for a time, and others think it of no importance. The bar while hot is cut into lengths and piled, five pieces being put and heated together in the "balling" furnace, or repeating. When the faces are brought up to a welding heat, and the whole mass softened, it is again taken to the hammer (some rolling at once), others returning the bloom into the furnace, to bring up the heat again. It is then rolled out into the finished bar, of suitable size and thickness for the kind of plates required.

Some manufacturers have made very good iron from the puddled ball direct, and saving in wasters and improving the quality, but as the labor and number of hands were reduced by this mode, the men struck against it, and spoiled their work if not well looked after. This kind of iron was homogeneous, and not fibrous, as the iron "piled" and brought through the reheating furnace. The "shingler" must be very careful to form a second bloom under the hammer, and the bloom should be upset once or twice, so as to secure a welding of all the rough edges. If, after the shingling, the bloom has lost too much heat, it should be reheated. Care and expedition will remedy that necessity, and the reheating furnace may be dispensed with alto-

gether. The saving is much in cost and waste; the trouble with the workmen great. Some also produced very excellent iron from the puddling furnace by adding to the charge about 60 pounds of scrap or shearings, the trimmings of the plates when cut to size. The 60 pounds of shearings were thrown into a bath of saturated solution of nitrate of soda, and added to the charge during the "boiling." The advantages gained were—the scrap iron improved the charge in the proportion it bore to the whole mass; it was melted down quickly without waste, as the smelting took place under the surface. The weight of solid cold iron would take it to the bottom of the charge, carbon would be eliminated by fusion with the nitrate, and thereby improve the quality of the charge again. The ball was treated in the same way as ordinary puddled balls afterwards. The iron was tough as charcoal iron, but the characteristics of puddled iron arising from crudities for crystals unreduced were not exterminated but greatly reduced. A careful puddler can at all times prevent these crude lumps to a very great extent. Another saving arising out of the process was that the scrap "shearing" formerly put into a furnace and reduced to a welding state, hammered out and rolled, gave only a return of 13 cents to the ton, whereas the other returned the full weight of the shearings. Difficulties with the union men prevented them from pursuing this mode of manufacture.

The Tin Mills.—The bars are cut up into the required sizes, brought to a cherry-red heat in a reverberatory furnace, rolled out to a certain length by gauge, "doubled" and returned to the furnace rerolled, again doubled, heated and reheated. The several foldings of the sheets adhere slightly.

After the sheets are cut down to size for tinning they are separated from each other by what is called opening; during the process of opening, "stickers" and imperfect plates are thrown out, and the passed sheets then go into the "pickling room." There they are put into a hot pickle of dilute sulphuric acid, to be cleansed from oxidized and silicious matters, and undergo another rough examination in the "scouring process;" that is, any plate not cleansed is rubbed with sand in water. Defective sheets are again thrown out, and the sheets or plates are now passed into the annealing room.

The annealing furnace is a large reverberating furnace capable of holding several annealing pots. The pot is composed of a stand of sufficient size to take the sheets, with a raised rim. Several hundred sheets are piled on the stand, and a square, box-shaped cast pot com-

plates the pot. This is inverted over the sheets, and the space between the rim of the stand and the rim of the inverted pot is filled with oxide of iron, to lute it down and exclude the air. The pots are then put into the furnace until it is full and the whole brought up to a cherry-red heat, or a little beyond. About eight hours are necessary for its perfect saturation by the heat. When removed from the furnace they are slowly cooled in a place free from draft and then the pots are opened. The plates never lie perfectly flat, and should be of a dark straw color at the edges. If the air should get in in small quantities, a deep blue color will cover the sheets more or less. The plates adhere slightly, are again separated, and ready for the second pickling room. The plates are then submitted to a hot but more dilute pickle of sulphuric acid, and again chemically cleansed; taken from the acid bath they are well washed in running water, and kept in clean water until the tinman is ready for them.

The Tin House.—The tinman takes the plates from the water-bath (where they lie some hours) and plunges them wet into a bath of hot palm oil called the “grease pot.” When they have acquired the temperature of the grease pot they are removed with tongs and quickly submerged in a bath of tin. The oil mixed with the water from the plates floats at the top, forming a flux to cover the melted tin and prevent oxidation. With the tongs, the sheets or plates are continually kept moving and separated, to insure the tin getting between all of the sheets. When the bath has recovered its heat, which it generally does in about half an hour, the tinman examines the charge, and finding that perfect amalgamation has taken place between the two metals, he removes them, in quantities convenient, with a tongs, to the next bath, which is kept at a low temperature.

The temperature raised by the change from the “tinpot” is again allowed to cool down to a few degrees over the melting point of the tin, when the plates are taken in lots of a dozen or two at a time, and laid on an iron slab which is at the side, or head of the pot. The waste metal and grease run back into the pot, the slab being inclined. The workman then takes up sheet by sheet in the tongs, and dips each into another bath of fine metal kept at a heat a little over melting point, immediately withdraws it, and places it in a rack immersed in a large pot of melted palm oil kept at the proper temperature, where they are allowed to remain a certain time. The sheets are then slowly lifted out of the grease by a boy, who separates them

into proper lots by counting carefully, regulating the intervals of time between them. The grease recoils from the top plate, and as little is left on the sheets they are again placed in a rack in the open air to cool; when cool a lad takes each sheet in a tongs, and dips the lower edge into a small bath of melted tin, so regulated that the sheet can only enter to about the eighth of an inch. It is kept long enough to melt off the drops of metal which adhered to the lower edge, and when lifted the sheet is struck to throw off the superfluous metal from the edge. The plates are again put into a rack, and taken while warm to a bin of bran, where each sheet is thrust into and under the bran, to get rid of the grease which adheres. It is then passed on to a second and third hand, when the grease is pretty well left behind in the last bin, which is kept filled with new bran. The sheets are turned out covered with flour dust and bran, and dusted off with cotton shaggy cloth. The next process is in the sorting room.

The finished sheets are laid on tables, and each sheet undergoes an examination by the sorter, who throws out those shearings which are defective in the iron or trimmings. The latter are reheated to regain the tin; the imperfect sheets are sold as "wasters" at a less price; the sheets are counted, and the box of 100 weight is composed of 225 sheets of 14x10 for home use or for exportation.

ON SOME RECENT IMPROVEMENTS IN THE MANUFACTURE OF ARTIFICIAL STONE, AND THE APPLICATION OF SUCH STONE TO CONSTRUCTION AND OTHER PURPOSES.

By FREDERICK RANSOME, Esq. (of England).

After the reading of the paper by Mr. Ransome, at the Massachusetts Institute of Technology, at Boston, U. S. A., on the evening of Thursday, November 13th, 1873, the following observations were made during the discussion which ensued thereon:

Dr. T. STERRY HUNT, LL.D., Professor of Geology, expressed his satisfaction at the beautiful results arrived at by Mr. Ransome, who, after years of experiment, had solved satisfactorily and completely a great industrial problem. He had followed with the more interest the labors of Mr. Ransome during many years, from the fact that he himself had formerly carried on, in 1857-58, a series of experiments very similar in character and in chemical results, in his endeavors to find out the method by which certain soft earthy rocks, consisting in

great part of silica and carbonate of lime, have become hard and crystalline. The speaker had shown, by researches in the laboratory and also by observations of limestone strata in the vicinity of eruptive rocks, that a reaction between silica and carbonate of lime takes place in the presence of carbonate of soda, by which the alkali brought about, little by little, the solution of the silica, and its union with the lime to form a hard silicate of lime. This is nature's method. The action of alkali in dissolving the silica and then again giving it up to the lime, was an example of many of the so-called actions by presence, which are really cases of ordinary chemical affinity acting under peculiar conditions. It was reserved for Mr. Ransome, by using both the lime and the silica in their free, soluble and active forms, and by bringing in the alkali already combined with a portion of silica, to make this curious reaction very rapid, and to show that the product forms a cementing material which is available for binding particles of sand into hard, stone-like masses. Mr. Ransome has also shown that the small amount of alkali used in the process itself, unites with the successive portions of silicate of lime formed, and becomes locked up in an insoluble compound, as in the case with alkali in granite rocks. Hence the new artificial stone, unlike the earlier products obtained by Mr. Ransome and by others, contains no soluble salts to be got rid of.

In reply to a question as to the fitness of artificial stones like this to resist the effects of fire, Dr. Hunt compared its constitution with that of granite, in which an important element is a vitreous crystalline quartz. This cracks like glass when exposed to sudden changes of temperature, and thus produces a sudden exfoliation or crumbling of the granite, as was well seen in the great fire of Boston, in 1872. On the other hand, sandstones of really homogeneous character, which consist of small grains of quartz bound together by a cement, are among the substances best fitted to resist these changes of temperature. He alluded to his observations of materials like the Potsdam sandstone of Northern New York and Canada when exposed to conflagrations, and said that the material made by Mr. Ransome's process is an artificial sandstone, and would, he conceived, be eminently fitted to resist the effects of fire.

JOHN M. ORDWAY, Esq., A.M., Professor of Metallurgy and Industrial Chemistry at the above College, said: Some fifty years ago Fuchs discovered that peculiar adhesive compound of alkali and silica called "water-glass," and it has ever since been a problem how to render this solution of sand available for the manufacture of artificial

stone. Fuchs himself made mixtures of the potash and soda silicates with sand and other inert substances, and thus produced solid masses having great tenacity, but the cementing material still remained soluble in water. Others have tried water-glass for hardening soft and porous natural stones, as well as for making a concrete of coarse powders, but without important results.

Mr. Ransome appears to have been the first to remove the alkali or render it insoluble after moulding the mixed materials into any desired form, and he has thus rendered silicate of soda practically useful in the production of a firm stone capable of resisting all atmospheric agencies. His first mode was to submit the moulded mass to a heat sufficient to cause the silicate to combine with the surfaces of the sand particles, and thus make an insoluble vitreous cement throughout the entire mass. The results were satisfactory, but in carrying out the process many practical difficulties were met with, and these were mostly overcome by very ingenious devices on the part of the inventor. Still the drying and burning required care, labor and fuel, and it was felt to be highly desirable to produce an equally strong stone altogether in the wet way. This end was at length reached by the use of chloride of calcium as a fixing agent.

Thus was developed the second plan, which soon proved to be an improvement of the highest importance, for it rendered possible the use of the stone for a much greater variety of applications.

To allow the chloride of calcium to soak in, and the resulting chloride of sodium to soak out, a certain degree of porosity was essential, and therefore very fine materials could not be used. Moreover, it was obviously difficult to effect a complete conversion of the soda silicate into a lime silicate in the interior of a thick mass of the moulded mixture. So a further improvement was desirable: and finally Mr. Ransome succeeded in using such materials for cement as would of themselves become insoluble and require no after treatment with chemicals. Thus a stone can be produced of any desired thickness and solid throughout.

This is effected by adding to the ingredients hydraulic lime and active silica, the active silica being in time transferred through the agency of the alkali to the unsaturated base of the hydraulic lime—while the soda also itself unites with the silicate of lime to form an insoluble double silicate of lime and soda. Thus, the persevering inventor appears now to have reached the highest degree of perfection of which a water-glass cemented stone is capable.

It has been maintained, and the view is coming to be generally accepted, that the hardening of hydraulic and Portland cements is in a great measure owing to the transferring power of a small portion of alkali which such cements are generally found to contain. Mr. Ransome's last process there is an intensifying of the reactions which take place in the solidification of ordinary hydraulic cement, while the product is made very much richer in combined silica, the substances which afford the greatest resistance to atmospheric and abrading agencies. The hardening is accelerated by the use of water-glass, and, instead of ageing for days or weeks, a very resistant stone may be made in a few hours. Hence this process is of especial advantage for engineering work demanding rapidity of operation.

It may be of interest to mention that some of the bricklayers of Boston have been for years accustomed to take advantage of one principle involved in Mr. Ransome's last process, and by so doing, to make the poorer qualities of hydraulic cement equal to the best. It often happens in plastering a continuous surface, as a cellar floor, that owing to some defect in the material the coating remains a week or more without setting. In such cases, if a dilute solution of water-glass is sprinkled or brushed on, the cement becomes firm and resistant in one hour or two.

Franklin Institute.

Proceedings of the Stated Meeting held October 15, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the previous meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at their stated meeting, held October 8th, donations to the Library had been reported as follows :

Journal of the Statistical Society of London, for June, 1873. From the Society.

Journal of the Chemical Society of London, for May, June and July, 1873. From the Society.

Journal of the Society of Arts of London, for July, 1873. From the Society.

Proceedings of the Royal Society, Nos. 138—145 (1873). From the Society.

Monthly Report of the Chief Engineer of the Manchester Steam Users' Association, for May, June and July, 1873. From the Association.

Proceedings of the American Philosophical Society, Philadelphia, January to May, 1873. From the Society.

Proceedings of the Royal Institution of Great Britain, vol. vi, parts 5 and 6. From the Institution.

Mittheilungen der Geographischen Gesellschaft in Wien, for 1872 From the Society.

Report on a Topographical Survey of the Adirondack Wilderness of New York. From Verplanck Colvin, Esq.

The Journal of Applied Sciences, January to May, 1873, London. From the Editor.

The American Ephemeris and Nautical Almanac, for 1876. From Prof. J. H. C. Coffin, U. S. N.

Contributions to our knowledge of the Meteorology of the Antarctic Regions. From the Meteorological Society, London, 1873.

Résultats of a Series of Meteorological Observations made under Instructions from the Regents of the University at sundry stations in the State of New York. From the Regents of the University of New York.

The 83d, 84th and 85th Reports of the Regents of the University of New York, 1870, 1871, 1872. From the Regents of the University.

The Fifty-fifth Annual Report of the Trustees of the New York State Library, 1873. From the Regents of the University.

Civil List and Forms of Government of the Colony and State of New York : Albany, 1869. From the same.

Manual for the Use of the Legislature of the State of New York, 1871. From the same.

The Actuary likewise reported the minutes of the several standing committees.

The Committee on the Mode of Determining the Horse Power of Steam Boilers presented two reports which embodied their views. It was, thereupon, on motion, resolved, that while not adopting the views of either report, the Institute accepts the same ; and further that both reports be published in the Journal for the information of members. Mr. Edward Brown, the Chairman of the Committee, then gave a brief history of the work of the Committee, and concluded by urging

its discharge. It was, thereupon, on motion, resolved, that the Committee be discharged, and that the thanks of the Institute be presented to the gentlemen composing it, for the faithful manner in which they had performed their laborious task. The reports in question will be found published in the Journal for December, 1873.

The President next announced a paper, by Mr. William M. Henderson, upon "An Improved Hydraulic Railroad Car Brake." The paper, together with the discussion which it elicited, will be found published in the Journal for December, 1873.

The Secretary then presented his monthly report on Novelties in Science and the Mechanic Arts.

The Committee on Conflagrations reported progress, and was continued.

Under the head of new business, the President announced the receipt of a communication, signed by sixteen members of the Institute, requesting that the Reading Room and Library of the Society be opened on Sundays between the hours of 10 A. M. and 3 P. M. The subject elicited considerable expression of opinion, favorable and unfavorable, participated in by Messrs. LeVan, Orr and Close. A motion to defer action upon the subject until the November meeting finally prevailed.

The Secretary then announced the presence at the meeting of Messrs. David Brooks, Thos. S. Speakman and J. E. Mitchell, the representatives of the Institute at the Universal Exposition at Vienna. The President thereupon signified to the gentleman named the desire of the meeting to receive any communication which they might be prepared to make.

Mr. Brooks, in response, remarked that his attention had been devoted mainly to the subject of electrical science and its application to the telegraph and other practical uses. "There was not so much that was especially new or novel in electrical matters at the Vienna Exposition, as there was of improved constructions indicating scientific progress. The articles and processes there exhibited were mainly in the direction of perfecting what was hitherto well known.

"Amongst the novelties were the Gramme machine, the magnets of M. Jamin, and one of Siemen's, of Berlin. The performance of the Gramme machine was shown by the melting of wires, the production of brilliant luminous effects and rapid chemical effects. A magnet of Jamin's, weighing one hundred pounds, was there exhibited, which supported a weight of five hundred pounds in addition to its own armature, weighing twenty five pounds.

"An immense magnet, by Siemen's, of Berlin, was also displayed, which, weighing several tons, and rotated by steam power, produced magneto-electric force

sufficiently powerful to support a flame of such brilliancy that it could not be looked upon with the naked eye, even when the spark was in the light of the sun at mid-day.

"In Telegraphy, the speaker further remarked, the European practice is far in advance of our own, especially in the direction of making the telegraph reliable and cheap.

"A dispatch can be sent as far in Germany or France for twenty cents as in this country for one dollar. The instruments used are the Morse or the Hughes', both American inventions.

"The Hughes' is the instrument generally in use on the Continent. The speed of this instrument is about twice that of the Morse, and the dispatch is transmitted and delivered in plain Roman letters. This instrument requires well insulated lines, and consequently is used to a very limited extent in our own country.

"In all the cities and large towns of Europe, the wires are laid underground, and the appearance of the streets and avenues is not marred by unsightly poles and wires.

"In Paris, Mr. Brooks further added, the dispatches are sent from the central station to the branch stations through pneumatic tubes; they are likewise sent from the branch stations to the central station by the same means, and thence transmitted by the wires to their destination."

On behalf of Mr. Speakman, the Secretary read a lengthy report, which that gentleman had prepared, of his observations abroad, particularly describing in all its details the process of manufacturing tin plate as practised in Wales. The paper will be found published in the *Journal* for January, 1873.

Mr. Mitchell, upon being called upon, begged to defer his remarks until the November meeting, when, he announced, he intended to discuss the bearing of the Vienna Exposition upon the Centennial Exhibition to be held in Philadelphia in 1876.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*

A New Bridge over the Hudson.—The corner stone of the new bridge to cross the Hudson river at Poughkeepsie was laid with much ceremony on the 17th ultimo. The new structure will be of the truss pattern. Its total length will be 2420 feet, with 1080 feet of land approaches; it will rest on four piers in the river and two abutments, giving five spans of nearly five hundred feet each. The piers will rise 210 feet above the river bed, and the trucks will be 194 feet above the water level. The cost of the work is estimated to be \$2,400,000, and will be under the engineering charge of Mr. O. H. Linville.

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No. 2.

EDITORIAL.

ITEMS AND NOVELTIES.

Jones' Self-regulating Steam Trap.—The advantage in many instances, and the necessity in some, of an automatic device by which the water of condensation can be discharged from the end of a coil of heating pipes as fast as formed, without allowing the escape of steam, or by which an engine at a considerable distance from the boiler can be relieved from the injurious effects resulting from working water through it, are too well known and too generally appreciated to require comment.

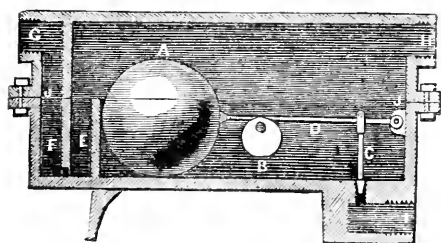
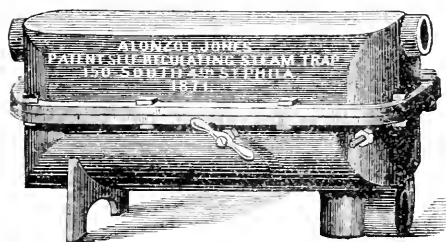
The means generally used to this end have depended upon the differential expansion of metals, but though machines constructed upon this plan in some instances answer pretty well at first, they are constantly liable to fail, owing to the well-known fact that, after some time, metals cease to expand and contract regularly under changes of temperature to which they have become accustomed. The force of gravity has also been used by means of a ball-float, to which is attached a valve, and which, rising as the chamber in which it is contained fills with water, raises the valve and allows the water to escape as fast as it enters the chamber. These are liable to two objections: first, that the balls cannot be made sufficiently large to be able to lift

against any considerable pressure of steam a valve large enough to relieve pipes in which water condenses rapidly without losing the strength necessary to prevent collapse, and, second, that the balls, which practically cannot be made entirely tight, gradually fill and become water-logged.

The instrument now under consideration provides against these difficulties in the following manner.

It consists of a cast-iron box, having inlet and outlet pipes, and

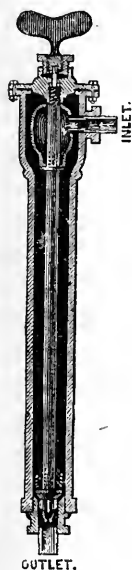
containing a ball-float attached to a lever, which, at the other end moves upon a pivot, and to which, near the pivot, is suspended a valve. The lifting force of the ball being thus supplemented by this leverage, it is able to open a valve sufficiently large without expansion to an impracticable size; still it is liable to leakage, to counteract which the lever is made hollow; the pivot upon which it moves is a hollow T, into which it is screwed. One end



of the T is plugged and into the other end is screwed a small tube which passes out through the side of the trap through a stuffing-box. Thus while the ball is free to move with the rise and fall of the water, a free passage is always maintained from the inside of the ball to the outer air. The ball being under steam pressure must be always at a temperature exceeding 212° , and any water that may leak into it being only under atmospheric pressure, must be instantly evaporated and the ball must be kept empty. When steam is first turned on to a coil of pipes, it is desirable to relieve them of the contained air, to do which the ball and valve are temporarily raised by a cam under the lever, whose axis passes through a stuffing-box to a handle outside, and to prevent freezing, should there be danger of it when the steam is turned off, the valve is opened by the same cam and the trap is drained.

Fire Extinguisher for Ships.—A suggestion of Dr. Schupert, of New Orleans, for the purpose of extinguishing fires on ship-

board, seems practical enough to merit reproduction. According to his plan there are to be placed at given points, in the hold of the vessel, boxes, furnished with a supply of marble waste. Each box is to be brought into communication with the deck of the vessel by means of lead pipes, terminating in a funnel or other convenient manner. Should a fire be discovered in the hold, sulphuric acid is poured down the pipes; and this, coming in contact with the marble, causes the active evolution of carbonic acid gas, which finds its way in quantity with the hold, through perforations in the boxes, surrounding the cargo with an atmosphere which is a non-supporter of combustion. As the carbonic acid gas is much heavier than the air, it is anticipated that it will not escape in any considerable quantity until the hold is filled to overflowing.



Jordan's Steam Trap.—In mines, rolling mills, and wherever steam has to be carried some distance through pipes from boilers to engines, pumps, etc., many accidents occur from the water arising from condensation of steam getting into the cylinders, etc. In such cases the use of an effectual steam trap is a desideratum. The following is a description of a machine similar in construction to the globe valve, consisting of an iron body or case, 24 inches long, with a brass seat for an inch valve, which valve is attached to a brass perforated tubular stem, the upper end being threaded and held in place by passing through a cap, like the stem of a globe valve. By this means it can be opened and shut like a valve, or set to work by the difference of expansion of the iron body and the brass valve stem, steam heat shutting it and the lower temperature of the water of condensation opening it. The opening being proportioned to the temperature, when there is great condensation and the water colder, the valve is wider open, as there is more water to discharge. It is claimed for this trap that it is of very superior quality, with regard to quickness of action, amount of water discharged, in prevention of loss of steam, and in being non-freezing.

A New Application of Steam Power.—The *Dental Cosmos* contains a communication from Dr. J. Frederick Babcock, in which the writer states that he has for the first time and successfully employed steam power in dentistry, and heartily recommends its use to his

professional brethren. The motor employed is the "Morrison Engine," for which special advantages to this end are claimed. Referring to the character of the work, the writer says: "The action of the drills is much more perfect, being made steadier. The speed is more fully under control, and may be made very much greater or very much slower than is possible by foot power. The treadle is abolished and, of course, the tiresome action of the foot and leg with it. The operator has as perfect control over his body as though he were doing nothing in the way of work. * * * Every operation performed upon the teeth, excavating, putting in the gold, finishing, polishing, separating, etc., I now do by steam power."

The Canal in Winter.*—When Mr. Robert Chesebrough published his scheme for keeping canals open in winter by warming the water, his project was received with such general ridicule, that we believe this journal stood alone in granting its author the possession even of common sense. But Mr. Chesebrough has now published a second pamphlet containing opinions by Prof. Thurston and Dr. Van der Weyde upon his scheme, and they both take ground similar to our own—that is, that the plan proposed is no way deserving of ridicule, but does fairly merit careful investigation. Prof. Thurston has gone into the subject very carefully and comes to the conclusion, also independently expressed by us, that the problem contains elements which have never been determined, and which are worthy of attention. These questions are: the amount of ice which forms during the winter, the amount of protection it affords the fluid water, the effect of boats keeping the thin ice broken up, etc. Eliminating all but the first of these, and estimating that the average thickness of ice formed in the Erie canal during the winter at two feet, he finds that one mile of canal, 35 feet wide, would be covered with 369,600 cubic feet of ice; and this would require 3,020,001,600 British thermal units to melt it. A ton of anthracite containing 90 per cent. of carbon and giving out 75 per cent. of heat produced, would yield 10,000 thermal units, so that the ice on one mile of canal would be melted by 302,000 lbs. of coal, or 138.8 tons; allowing, also, 10 per cent. for loss of heat in warming the water, he arrives at the round number of 150 tons per mile. His estimates, therefore, differ from those of Mr. Chesebrough, and in their financial calculations they separate still more widely. Prof. Thurston points out that the in-

*From the *Engineering and Mining Journal*.

tensity of cold in winter is not a regular thing, and that the apparatus must be made large enough to answer for the coldest days. This increases the first cost to \$12,000 per mile, and the running expenses are estimated at \$3,520 per mile. This is for a canal of 35 feet wide. If the prism is made 70 feet wide, as proposed, the expense will not be doubled, but will amount to \$22,500 for plant and \$6,305 for running expenses.

These items are, however, modified by various considerations. Thus, steamers are used as ice breakers, and if they are supplied with condensing engines they would act as moving ice melters as well as ice breakers. If canal boats are to be propelled by steam, a proposition which is extremely probable, they could by law be compelled to use condensing engines, and by their number they would contribute very materially to the amount of heat supplied to the water. Their movements, too, would have an important effect in breaking up the ice, so that a whole fleet proceeding along the canal could make its way at an expense which would not be great for any one boat. In fact, ice does not form so readily in agitated water as in still water, and thus the boats would contribute a mechanical means of preventing the formation of ice.

Taking all these points into consideration, Prof. Thurston says : " If the capacity (of the heating apparatus) were such that it would be capable of destroying ice one inch thick in twenty-four hours, or possibly even somewhat less, the steam ice-breakers would be able, at comparatively moderate expense, to keep the channel open in all but the coldest days of the winter, until the extreme cold weather had passed, and thus the heating apparatus could be given more nearly a capacity for average work as proposed, its expense would be correspondingly reduced and the total expenditure per annum would approximate to a maximum. The favorable circumstances already described would in this case also find their fullest development. Proceeding on this basis, which should be regarded simply as representing my individual views, my estimates would become for a canal 70 feet wide :

Cost of plant per mile :

Heating apparatus	\$12,000
Distributing apparatus	2,500
Buildings and land	1,250
Total	<hr/> \$15,750

Cost of maintenance per mile and per annum :

Repairs and depreciation	\$1,450
Interest on capital	1,102
Coal—300 tons at \$4	1,200
Two men—three months, at \$60	360
One man—four months, at \$60	240
One man—three months, at \$90	270
Superintendent and contingencies	150
Total	<u>\$4,772</u>

Total estimates for canal 350 miles long, 70 feet wide, in the latitude of central New York :

First cost, 350 miles, at \$15,750	\$5,412,500
Maintenance per annum, 350 miles, at \$4,772	1,670,200

Professor Thurston, as we said before, thinks the scheme deserves investigation, and that an engineer of proper ability would be able to determine the doubtful points without difficulty and at very moderate cost.

Mr. Chesebrough dissents from the estimates of Professor Thurston, but these financial questions are not at present the interesting ones. Enough has been shown to warrant a full trial of the project. He makes a new suggestion, however, upon which we will have a word to say. It is, that ice might be prevented from forming by pouring petroleum on the water, a thin film of this fluid being an effectual preventive of ice; also that if thick ice forms during a cold snap, it can be made very rotten by burning benzine on the surface. Unfortunately, there is experience on record of rivers covered by petroleum, and this experience is not of a kind which can encourage its intentional use. A canal that is lined in every mile of its length with buildings and boats that are too valuable to be lightly exposed to fire, and we hardly think the suggestion is one which can be carried out.

Lake Superior Tin.—The accounts which are from time to time received from the tin fields of Australia, are in the highest degree gratifying; and indicate that at no distant day the commercial importance of that Island will be greatly enhanced by its production of this metal. In the Kœting field the ore occurs as black, grey, yellow, and ruby tin, and is often coated with oxide of iron; small garnets are frequent and specks of gold are occasionally met with.

Excellent prospects have been obtained over an extensive district

in the Kœting field, and the development of tin deposits is looked forward to with confidence as likely to add at once very materially to the wealth of the colony. In the first nine months of 1873, ending September 30th, there were imported from Australia into England, 3,520 tons of tin ore, while during the corresponding period of 1872, the amount imported amounted to only 200 tons; a state of affairs which affords the best evidence of the value and genuineness of the newly discovered deposits.

The large importations from Australia, combined with commercial causes, have caused a decline in the prices of the ore, as well as a reduction in the supply from other sources.

While upon this theme, it may not be amiss to state, that recent developments have brought to light the fact, that the reputed discovery of valuable tin deposits on the North shore of Lake Superior, which were extensively circulated by the mining press of the country upon what appeared to be very substantial evidence of genuineness, is another disgraceful attempt at swindling upon an altogether unprecedented scale.

The following letter written by a correspondent of the *London Mining Journal*, will sufficiently explain the condition of things, and renders comment unnecessary.

SAULT STE. MARIE, JUNE 21st.—*To the Trustees of the Otter Head Tin Pool.*—In November last, I made a cursory examination of the supposed tin lands near Otter Head, on the North shore of Lake Superior, spending only about two hours on the ground, the threatened immediate closing of navigation preventing a longer stay. I took specimens from two veins which I thought contained tin, and a careful assay proved the fact to our satisfaction. Having just returned from making a closer examination of the same lands and veins, I desire to report that I found unmistakable evidences that, by artificial means, tin had been placed in the fissures and veins, probably in liquid form, which afterwards assumed the appearance of artificial stone containing the metal. As proof that such was the case, I found buried near these veins, four barrels of silicate of soda, a box containing clay, and other materials, which I suppose to have been used in carrying on the deceptions practiced upon the gentlemen who made the necessarily hasty examination in November, 1872, in company with Mr. Pennock. I found the original vein; the matrix had been worked out with a pick for some depth, and then filled with an artificial rock containing dressed tin of a high per centage. I must admit that, at the

time of my first visit, I was deceived, and attribute the deception to the very short time given us for examination, which under the circumstances could not be thorough, and now declare it a fraud and swindle, perpetrated, aided and abetted by men whom I could not believe would be guilty of so base a transaction. I regret ever having seen or heard of the property, yet it may prove valuable in other minerals, which I hope may be the case for all interested. WM. HARRIS.

The British Exports of Coal for the nine months ending 30th Sept., by the Board of Trade Returns, amounted to 9,444,464 tons, of the value of £9,924,272, being about 650,000 less in quantity, and £2,700,000 more in value than for the same period of 1872. For the month of September the exports of coal were 1,134,893, of the value of £1,168,441, being 74,000 tons less in quantity than for September, 1872.

Can Electricity be Profitably Employed as a Source of Power?—There was recently on exhibition in one of our industrial expositions a series of pumps, worked by exhaust steam, over which was placed the startling announcement, that, by means of them, water might be raised to a given height in quantity sufficient to drive a water-wheel which would give out more power than the steam-engine itself! The placard was well calculated to attract attention, but then nobody believed the statement printed on it, for the simple reason that no engine, far less the exhaust steam from one, could ever pump up water enough to drive a wheel which would give out half the amount of power of the original motor. The waste in pumping and the loss caused by want of efficiency in the water-wheel would be sure to consume the other half. Now it happens curiously enough that there are in common use two methods for producing dynamic electricity—one being the voltaic battery and the other any form of mechanical power. In regard to the latter, it is evident that the same principle holds true in regard to it that is true when applied to the water-wheel and steam-engine above mentioned. If electricity, which has been produced by the agency of mechanical power, be applied to the driving of an electro-motor, the latter can never be made to give out as much power as has been exerted by the engine employed to produce that electricity. In other words, no one could be found so foolish as to employ a steam-engine to produce electricity for the purpose of operating an electro-motor intended to drive machinery. It would evidently be vastly more economical to drive the

machinery by means of the engine itself, without the intervention of any complicated apparatus.

This proposition is so self-evident that it requires no elaborate demonstration; but from it follows the very obvious conclusion, that, if by means of the steam-engine we can produce electricity more cheaply than we can by the voltaic battery, then it is evident that the battery cannot compete with the engine as a source of power, no matter how perfect may be the electro-motor through which the energy derived from the battery is applied. Hitherto it has been claimed that the only difficulty in the way of applying electricity as a motive power consists in the absence of a properly constructed electro-motor; but if it can be proved that electricity can be produced more cheaply by means of steam than by the consumption of zinc, then it is clear that even a *perfect* motor—that is to say one that utilizes *all* the electrical energy, and converts it into mechanical power—cannot enable the battery to compete with steam.

Here, then, is a crucial test which is easily applied. And we believe that the results already attained do not leave the question in any doubt. In the case of the electro-deposition of metals, as well as the production of the electric light—two instances in which the comparison between the engine and the battery may be made with great accuracy—it has been found that the engine is the most economical. *A fortiori*, it should be far more economical as a source of mechanical power.—*The Technologist*.

Russian Mining Industry.—The following information concerning the mining industry of Russia may be read with some interest. In 1871 the number of mines owned by Russia and producing gold were 979, platinum 6, silver 21, copper 76, iron 1174, zinc 6, cobalt 1, tin 1, coal 327, pyrites 1, chromium 6, rock salt 4, besides 697 naphtha pits. Their yield was, from 17,000,000 tons gold sand, 86,400 pounds of gold; from 168,000 tons of platinum sand, 4,504 pounds of platinum; 35,120 tons of silver ore; 100,365 tons of copper ore; 820,000 tons of iron ore; 42,400 tons of zinc ore; 10½ tons of cobalt ore; 8,000 tons of pyrites; 817,000 tons of coal; (stone coal and lignite); 22,000 tons of naphtha; 7,000 tons of chromic iron ore; and 455,000 tons of rock salt. The smelting works of Russia produced from these ores 29,000 lbs. of silver, 1,740 tons of lead, 4,200 of copper, 8 of tin, 2,700 of spelter, 354,000 of pig iron, 30,000 iron castings, 241,500 wrought iron, 7,000 steel, 350 copper sheets, 500 zinc sheets.

New Apparatus for Testing Oils.—The *Bulletin de la Société d'Encouragement* contains a description of Garnier's apparatus for testing the inflammability of petroleum oils intended for illumination, which is noticed as follows in the *American Chemist*: "It consists of a cylindrical box, having a wick supported in its centre, across the top of which is a curved metal rod terminating in the bottom of the cylinder at both ends. The oil to be tested is poured in to a fixed height, the wick is lighted, the cover is put on—leaving an air space above the liquid—and a thermometer introduced through an opening. As the temperature of the oil rises by conduction of the heat along the rod, the thermometer column ascends. When the flashing point—which in France is 55° C. (131° F.)—is reached, the puff produced by the explosion extinguishes the flame, and the reading of the thermometer gives the point sought.

Franklin Institute.

Proceedings of the Stated Meeting held January 21st, 1874.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the Stated Meeting held January 14th, 1874, donations had been received for the Library from the following:—

Ordnance Memoranda, No. 15.

Report of the Board of Officers appointed in pursuance of the Act of Congress, approved June 6th, 1872, for the purpose of selecting a breech system for the muskets and carbines of the military service, etc. From the Chief of Ordnance, Washington, D. C.

Pennsylvania Reports of the Inspectors of Mines for 1872. From William A. Rolin, Esq., Philadelphia.

Transactions of the Literary and Historical Society of Quebec, Session of 1872–1873. From the Society.

Columbus, Ohio, its History, Resources and Progress, with numerous illustrations. From Jacob H. Studer, Esq.

Results of an Experimental Inquiry into the Mechanical Properties of Steel. (Duplicate.) By David Kirkaldy. From the Author, London.

A Catechism of High Pressure, or Non-Condensing Steam Engines.

By Stephen Roper, Esq. From the publishers, Claxon, Remsen & Haffelfinger, Philadelphia.

Annales des Ponts et Chaussées, for July, 1873. From the Editor, Paris.

Verhandlungen der K. K. Geologischen Reichsanstalt for April, 1873. From the Society, Vienna.

Jahrbuch derselben for April, May and June, 1873. From the same.

Die Cephalopoden-fauna der Gosau Schichten in den Nordöstlichen Alpen. From the same.

Proceedings and Transactions of the Nova Scotian Institute of Natural Sciences of Halifax, 1873. From the Institute.

Minutes and Proceedings of the Institution of Civil Engineers, Session 1872-73, Parts 1 and 2. From the Society, London.

Journal of the Royal Geographical Society, 1872. From the Society, London.

Monthly Notices of the Royal Astronomical Society, for November, 1873. From the Society, London.

Message of his Excellency John F. Hartranft to the General Assembly of Pennsylvania, January 7, 1874. From the Author, Harrisburg, Pa.,

The Actuary likewise presented the minutes of the several standing committees.

The President next presented the following:—

REPORT OF THE BOARD OF MANAGERS FOR THE YEAR 1873.

Your Board report that during the year 1873 there have been added to the list of members 91 new names; resignations from 31 having been accepted, the increase of membership has been 60.

An effort has been made during the year to perfect a list of the life members, but it has not yet been accomplished.

Circulars were issued representing the desirability of increasing our list of members, and some persons, not residents of the city, have expressed their willingness to become contributing members.

The Treasurer's Report shows a balance on hand January 1st,

1873, of	\$ 1,350 19
Receipts during the year 1873,	10,393 57
Total,	<hr/> \$11,743 76
Expenditures during the year,	10,047 24

Leaving a balance on hand of \$ 1,696 52

A large portion of the receipts and expenditures are incident to the publication of the Journal. The most rigid economy has always been requisite to make this publication meet its own expenses. The Committee on Publications report that the financial condition of the Journal is better than it has been for

many years previous, there being a cash balance on hand at the end of the year, included in the general cash balance, of \$681.21; but in this connection it must be remembered that no portion of the Secretary's salary has been charged to the Journal, so that the pecuniary success of the Institute's publication is largely due to the fact that the Secretary of the Institute acts as Editor.

Additions to the Library during the year have been as follows :

Bound volumes,	168
Unbound volumes, including Journals, pamphlets, proceedings of Societies, etc.,	222
Total additions,	390

The Drawing School, which was enlarged during the year 1872, was this year placed under the charge of Professor Alfred C. Wernicke, and your Board are pleased to report very favorably of his management of the school.

No. of pupils (1st session),	92
“ “ (2d session, thus far),	64
Total,	156

The importance of this department becomes more evident each year. During the early history of the Institute, the only means which artisans had of acquiring instruction in drawing, chemistry and natural philosophy was through the instruction given in these halls. Now, the introduction of night schools as an adjunct to the public school system, has opened new means to this end, so far as regards chemistry and physics; but the real value and need of instruction in drawing has not seemingly effected a like result, and the school of the Institute is of the greatest importance.

An effort has been made to secure the services of volunteer lecturers for the course of 1873, with encouraging results; and your Board have to thank Prof. E. D. Cope and Dr. Henry Leffmann for their services in this direction; while in the list of volunteers for the last part of the course will be seen the names of such distinguished men as Profs. E. D. Cope, J. P. Lesley, G. F. Barker and Mr. S. Lloyd Wiegand.

The Optical Section has also arranged to hold two special meetings on evenings usually devoted to lectures, for the purposes of displaying illustrations by the magic lantern and oxy-hydrogen microscope.

Two awards of the Scott Legacy Premium have been made this year—one April 9th, to William Wharton, Jr., for his invention of a “Safety Switch for Railroads,” and one June 2d, to John H. Irwin, for his invention of a “Tubular Lantern.”

The Optical and Meteorological Sections have held regular meetings, but no new sections have been organized.

2 Your Board desire to call attention to the fact that, as the first steps were taken by this Institute that led to the selection of Philadelphia as the place for holding the great Exposition in the year of the Centennial of American Independence in 1876, it is of the utmost importance that not only each member of the Institute should individually exert himself to aid the Commissioners in their great work, but that the Franklin Institute itself, as the leading Soci-

ety of its kind in the land, should exert itself in the same direction. To this end there is need, urgent need, of a great increase in the number of our members.

By order of the Board,

COLEMAN SELLERS, *President*.

On motion of Mr. Chattard, the Report was accepted and ordered to be placed upon the minutes.

Upon the call for the Reports of Special Committees, Mr. Chas. S. Close, from the Committee on Conflagrations asked for its discharge, stating that the work of the Committee was practically finished by its elaborate report on the petroleum oils made at the meeting in April last. The Committee was thereupon, on motion, discharged, with the thanks of the Institute.

On behalf of the Committee on Dynamical Terms, the Chairman, Mr. J. W. Nystrom presented the following :

REPORT.

The Committee on Dynamical Terms, appointed by the Franklin Institute at the September meeting last, has examined the subject entrusted to it, and finds that great indistinctness exists among scientific bodies and writers, here and elsewhere, in the use of scientific terms in dynamics.

Each dynamical quantity bears a variety of terms, differently defined, while it would appear that each quantity needs only one term, with one definition.

The following list of dynamical terms is collected from the works of RANKINE, MOSELEY and BARTLETT, which terms appear to be not clearly defined, and to be employed by these writers, respectively, in order to convey different ideas:

Terms used in Dynamics.

Efficiency of force.	Total quantity of work.
Force of motion.	Actual work.
Force of action.	Total amount of work.
Working force.	<i>Vis-viva</i> , or
Quantity of moving force.	living force.
Quantity of motion.	Energy.
Mode of motion.	Actual energy.
Mode of force.	Potential energy.
Moment of activity.	Energy of motion.
Mechanical power.	Energy of force.
Mechanical effect.	Mechanical potential energy.
Quantity of action.	Quantity of energy.
Efficiency.	Intrinsic energy.
Rate of work.	Total actual energy.
Dynamic effect.	Work of energy.
Quantity of work.	Stored energy.

Many more terms may be quoted as unnecessary, but this list may be suffi-

cient to draw attention to the importance of establishing precision to the meaning of dynamical terms.

The Franklin Institute, being a body largely composed of persons engaged in the mechanic arts, as also in instructing students in mechanics, experiences great difficulty in carrying out its objects with efficiency from the indistinctness referred to. Hence it is believed,—

That it is highly desirable to determine the meaning of such terms, giving them definitions which will be generally acceptable throughout the scientific world, and to eliminate all which may be deemed unnecessary;

That such a work can be best accomplished by a national body of authority; and

That the Smithsonian Institution being such a body, this Committee recommends that the Franklin Institute request it to consider the subject and take such action as it may deem proper to bring about this desirable object.

FAIRMAN ROGERS,
J. VAUGHAN MERRICK,
LEONHARD G. FRANK,
JOHN H. TOWNE,
JOHN W. NYSTROM.

It was thereupon moved that the report be received and the recommendation therein contained adopted. On call of Mr. W. P. Tatham, the question was divided; and, on being put to vote, the motion to receive the Report was passed, and that to adopt its recommendation was lost. The request of the committee to be relieved from further consideration of the subject was agreed to.

On behalf of the Committee on the Celebration of the 50th Anniversary of the Institute, the Chairman, Mr. Coleman Sellers, reported that no large hall being available for the evening of the anniversary, the Committee had decided to engage the Musical Fund Hall for the occasion, and that a number of prominent members of the Institute had promised to deliver addresses on the evening in question. On motion, the report of the Committee was adopted, and it was ordered that when this meeting adjourned, it would adjourn to meet at the Musical Fund Hall, on Friday, February 6th, at the usual hour.

The Committee to draft a minute expressive of the sense of the Institute with regard to the death of Prof. Agassiz, presented through its Chairman, Mr. Hector Orr, a report, which after several verbal amendments was finally adopted, as follows:—

Whereas, The Franklin Institute has learned with deep regret of the death of Professor Louis John Rudolph Agassiz, therefore

Resolved, That in this event Zoological Science and the cause of Truth in general, have suffered a severe bereavement.

As the undisputed successor of Cuvier, he has stood for years the foremost naturalist of the age. In choosing our hemisphere as the field of his latest researches, he did the world a great service while he honored us, and in fixing his home in America, spending his life here and electing us the custodians of his grave, he has given our people a still nobler distinction.

The modesty of his announcements is as singular as the faithfulness of his investigations, and these united present him as a true apostle of the highest grade.

With the inevitable sorrow due to his departure a gratifying recollection mingles, inviting thanks to our brothers of Massachusetts, who made him welcome, in the name of the nation, at their own expense. Long as they shall lead the van in such emulation, Philadelphians will be prompt to acknowledge and appreciate the same. "The Athenians know what is right, but the Spartans practice it!"

Resolved, further, that a copy of this minute be sent to the family of Professor Agassiz, and also to the Governor of the State of Massachusetts.

HECTOR ORR,
J. G. HUNT, M. D.,
B. H. MOORE.

The tellers of the election for Officers of the Institute reported the following named gentlemen elected:

President.—Coleman Sellers.

Vice-President.—Robert E. Rogers.

Treasurer.—Frederick Fraley.

Secretary.—William H. Wahl.

Managers (to serve three years).—E. J. Houston, J. E. Mitchell, Charles Bullock, William Helm, William B. Le Van, Samuel Sartain, Enoch Lewis, F. B. Miles.

Managers (for one year).—George F. Barker, Theodore D. Rand.

Auditor.—William Biddle.

The President thereupon declared the gentlemen above named to be the officers elect of the Institute, and gave a brief address expressing his appreciation of the compliment of a reelection.

The tellers of the special election to determine whether or not the Library and Reading Room shall be opened on Sundays, reported the number of votes for the proposition to be 87; against, 42. The President thereupon declared it to be the will of the Institute that the library and reading room should be opened on that day.

Mr. E. F. Loiseau, of Mauch Chunk, was next introduced, and read a paper on the subject of artificial fuel, which will be found published in the Journal of the Institute for February, 1874.

Mr. T. C. Clarke, Esq., of Philadelphia, then gave a description of the iron bridge now in course of erection by the Phoenixville

Bridge Co., across the Schuylkill at Girard Avenue. The paper was illustrated by aid of the stereopticon, and specimens of the decorative work; and will be found published in the Journal for March, 1874.

Under the head of new business, Prof. J. P. Lesley announced the fact that a bill was now pending before Congress to cut down the appropriation for the publication of the Nautical Almanac from \$20,000 to \$10,000, and urged that an emphatic protest should proceed from the Franklin Institute against any such proposition to cripple so valuable and useful an institution. He offered, thereupon, the following preamble and resolution, which were unanimously adopted.

WHEREAS, The Franklin Institute learns with deep regret of the intention of the Government at Washington to curtail the amount of the appropriation for the U. S. Nautical Almanac;

WHEREAS, In the opinion of this Institute, the Nautical Almanac is one of the most practically useful of those efforts of American science which stand before the world unsurpassed by any other nation;

WHEREAS, In the economy of the management of this great national work, as well as in the accuracy of the details which it furnishes, the American Nautical Almanac is an object of necessity for commerce, and pride to our citizens, and a model to other countries;

Resolved, That the Franklin Institute respectfully petition Congress rather to increase than to diminish the appropriation for an object so catholic, so necessary, and so creditable to the country.

Mr. J. W. Nystrom then gave notice of his intention to present at the next meeting of the Institute the following, as an amendment to the By-Laws:

Resolved, That the Institute shall hold a social meeting on the second Friday of each month, from 8 to 10 o'clock P. M., except in the months of July and August.

That the members shall be at liberty to converse freely in the hall of the Institute during the social meeting; and

That no lecture or other meeting shall be held at the Institute during the social meeting.

The meeting then adjourned.

WILLIAM H. WAHL, *Secretary*.

Civil and Mechanical Engineering.

THE GUNPOWDER PILE-DRIVER.

BY F. C. PRINDLE, C. E. U. S. N.

The novel and efficient use of gunpowder in the mechanic arts, and its successful application to pile-driving, has now become pretty generally known in this country, but results and facts developed by its use are still eagerly sought by the engineering world.

In view of this, it has been suggested to the writer that the subject was of sufficient interest and importance to justify the presentation of some recent improvements in the construction of the apparatus, at this time, and to which he has consented to respond.

In order to facilitate a more intelligent understanding of the general features and advantages of this particular design, it will be necessary to refer to the peculiar requirements of a machine operated by this novel process, which does so much credit to its inventor, Mr. Thos. Shaw, of this city, and briefly describe and discuss the principal features of the construction of the several forms of machines heretofore used.

The enormous power developed by the explosion of confined gunpowder, as used in this process, calls in the first place for a strong and rigid framing to resist the sudden and severe strains imposed upon the guides when at work; and the close-fitting plunger entering the gun at every stroke requires a good degree of mathematical precision in the fitting of the guides upon which they travel; while the application of a friction brake to arrest and retain the heavy ram in position, at any point of its travel, involves the use of a special appliance for this purpose, and the consideration of other strains incident to its use, and to which the framing itself is subjected when not in operation.

Manifestly, then, the ordinary pile-driver frame is not adapted to this new order of things, and several attempts have been made, since this discovery, to produce a suitable framing that would satisfactorily fulfil all the requisite conditions without being unwieldy, and at a moderate cost. The principles involved in the process, and the efficiency of its action, were fully demonstrated at the outset, and to successfully harness this mighty engine, and place it in practical operation under safe and easy control, in order to utilize its power—

a question of mechanical construction alone—has been the problem under solution ever since.

The different arrangements and modifications of form devised to attain this end, and placed in operation, having come under the observation of the writer from time to time—two of the earliest forms of machines, though now abandoned, having successfully driven over 3,000 piles on works under his charge—has suggested the ideas embodied in the plan herein illustrated and soon to be described.

The first form of machine put to practical test, consisted of a wooden frame almost identical with the ordinary pile-driver, but having the ways or guides of cast iron made in short lengths with U shaped sections and secured to the inner opposing faces of the uprights.

The ram was caught and held in position at the highest point of its ascent by means of a pawl engaging with the teeth of a rack secured to one of the uprights, the pawl being ingeniously constructed so as to release at will by pulling a cord from below. This part of the apparatus, however, was soon superseded by a continuous friction brake, which was applied from one side of the machine, with its arm brackets bolted to one upright, and the brake bar of angle iron pressing the ram in a corresponding V groove against the opposite upright.

While this machine fulfilled the desired conditions as to weight and portability, it did not possess the more essential of strength and durability, and but two or three of this kind were built.

The action of the brake forced the uprights and guides apart, throwing the plunger out of line with the gun, and distorting the frame at every blow.

The next form was constructed largely of cast iron.

The uprights were cast in 5 feet sections, both in one piece, and connected together at each end on the back, with deep crescent-shaped cross bars or ribs, and the sections were bolted together at the ends. The guides were V shaped, sunk on the inner faces of uprights, and tool dressed, as were also the ends of the sections, so that their alignment was perfect.

The brake bar was located and applied as before, and the strain of its action was transmitted through the curved cross-rib connections, from one upright to the other, the tendency of which was to separate the guides.

This was a decided improvement in many respects, especially as regards rigidity; but the machine was excessively heavy and unwieldy, owing to the great amount of cast iron used in its construction.

The shocks and sudden strains to which it was subjected, however, soon demonstrated its want of durability, especially in frosty weather, when breakages were frequent, and it was finally, after many renewals and repairs, reduced to the scrap heap, though not until after it had successfully driven some 2,000 piles, over 1,000 of which were upon the work under the writer's supervision.

It is this machine and its operation which were illustrated and described in the June No. of the JOURNAL for 1872.

The next form of construction indicated a return to the combination plan of wood and iron framing. Cast iron guides, of V section, and tool dressed, were secured to the inner faces of the wood uprights as in the first plan, but the braces connecting the uprights together were made of cast iron, as last described, and bolted to them.

The friction brake, with the usual angle iron brake bar, was applied in the centre of machine from the rear, an arm of the ram projecting sufficiently to receive the brake. A central upright of cast iron in sections, was secured to the cast iron braces, and to this the outer ends of brake arms were pivoted.

The use of this machine soon developed a serious defect in the operation of its friction brake, the pressure upon the V guides from one side (illustrated by the relative direction of this line) acting like a wedge, easily spread them and forced the ram out of line. This necessitated the addition of a flat surface on the opposite side of the guides, at a right angle with the direction of pressure, for the flat part of the ram arm to press against, instead of the oblique surface of the V.

This V form of guides was next abandoned entirely, and a half dove-tail form adopted, and the cast iron guide plates were replaced by those of steel with the groove tool dressed.

This change was quite successful, and considerable work has been performed by machines of this construction, over 2,000 piles having been driven by one machine on works under the writer's charge. The combination of wood and iron, however, was unsatisfactory, the cast iron was unreliable, the brake apparatus directly in the way, and the weight of machine too great.

The experience gained by these repeated failures seemed to point to the necessity of returning to a metal guide frame entirely, and the next form produced was made of McHaffie steel.

The uprights were of T section, gradually diminishing in size from base to top, cast separately in about 5 feet sections, and ends bolted

together with fish plates. The guides were of half dove-tail section, projecting from flange face centrally and tool dressed, as also were the ends of the section, to secure the necessary alignment.

A double brake apparatus was attached, one on each side, and applied from the rear. The brake arms and brackets were of steel, and bolted to web and rear flange of uprights, and the brake bars were of the usual angle iron. The uprights and guides were secured the proper distance apart, by stout iron rods fitted with jam nuts, and passing through the side bars of framing, which were of wood, and bolted to flange of uprights and to the ladder; some dependence also being placed upon the dove-tail guides to assist and support each other through the gun and ram.

This plan succeeded well, and several fine machines, some as large as 60 feet high, and fitted with a steel gun of $8\frac{1}{2}$ inches bore, and a 3000 lb. ram, have been put afloat and in service in different sections of the country, with good results as to efficiency and durability.

The cost of the steel itself, and the somewhat difficult machine work required to fit it for use, the writer is informed, renders it still too expensive, and it is also too heavy and cumbersome.

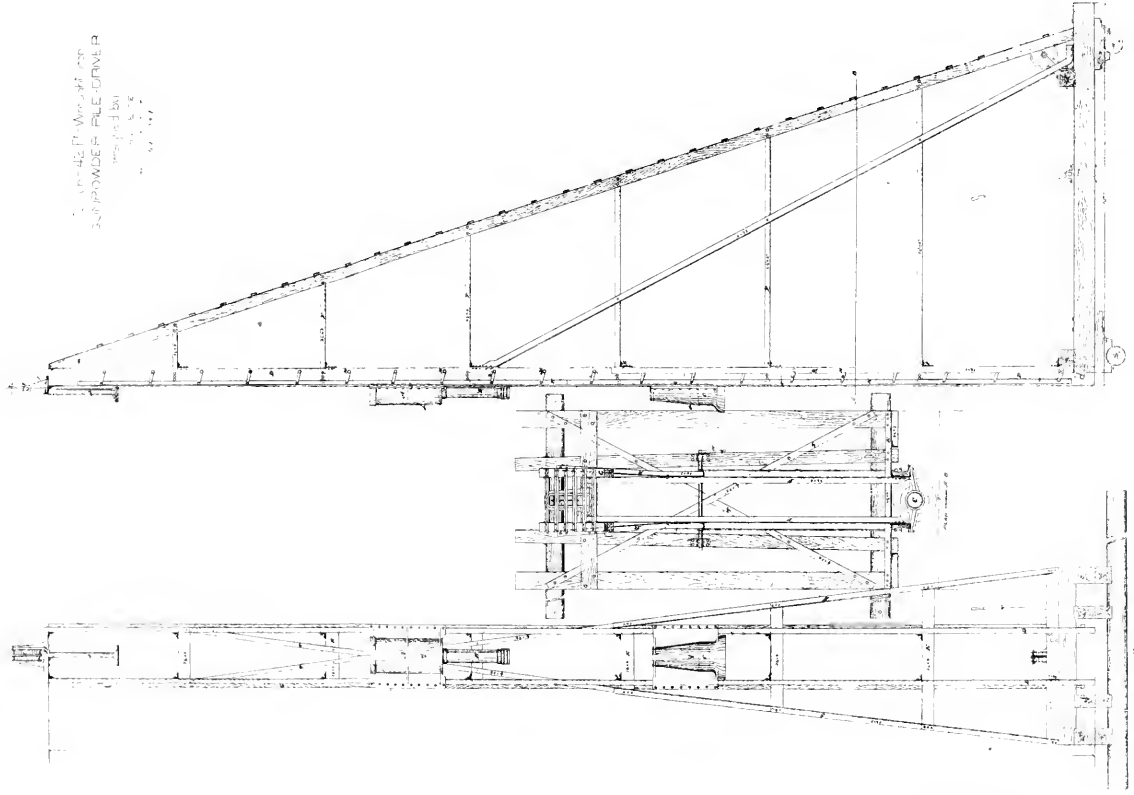
The design here illustrated from the working drawings, for a wrought iron frame, and which has been successfully tested, is next in order and will now be considered.

Referring to the plates, A is the ram, of cast iron, provided with its plunger B, upon the lower end of which is screwed a steel ring or band and turned to neatly fit the bore of the gun below—the whole weighing 2170 lbs. C is the gun, of steel manufactured by the McHaffie process, and weighing 1300 lbs. It has a bore $7\frac{1}{2}$ inches diameter and 24 inches deep, pointing upward, with its mouth slightly bell-shaped to receive the ram plunger at each stroke. Its walls are $3\frac{1}{4}$ inches thick at base, and the lower end is recessed to receive the head of piles. D D are the uprights of the frame, each consisting of a single piece of light nine inch channel bar of rolled iron, 42 feet long and weighing 50 lbs. per yard, with their flanges turned outwards, and the front flanges forming the guides or ways, up and down which both ram and gun move.

The uprights are firmly secured together the proper distance apart, by means of angle iron cross bars, E, riveted to the rear flanges, and spaced six feet apart. The side bars, F, of the framing are of angle iron also, one end of each of which is bolted through its vertical flange to the inside of the web of the uprights, and to the upper

42 P. WINDMILL POWDER MILL DRIVER

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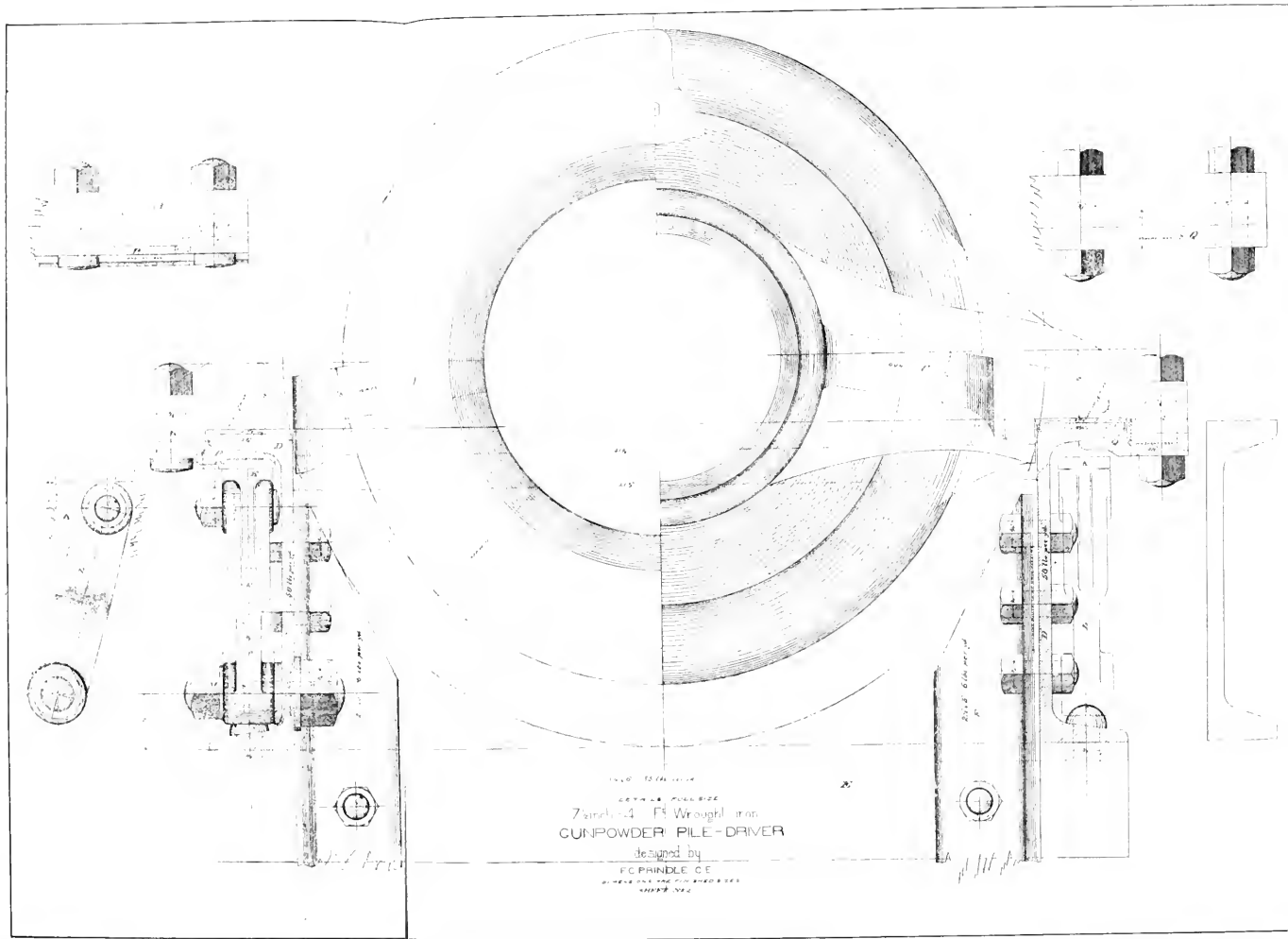
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flange of the cross bar through its horizontal flange, thus forming a sort of gusset stay or brace to stiffen the guides transversely, and the other end is bolted to the ladder, G, which is made of wood.

The cross-head, H, at the top of the frame, made also of light nine-inch channel iron, and secured to the uprights by angle iron brackets riveted on, carries the runner sheaves, I, and cushioning piston, J, bolted to its upper and under sides respectively. This fixed piston fits into a corresponding bore of the ram to form an air cushion, and prevent the escape of the ram from the guides when the height of its rebound is limited, as during the first blow with long piles.

The friction brake attachment, by which the ram is held in position at any point, is located (one on each side of the machine) between the flanges of the uprights, on the outer side, and consists of a brake-bar, K, made of very light T-iron, and brake-arms, L, made of McHaffie steel, spaced two feet apart and pivoted to the studs, M, in the web of uprights, and is operated by lever, N, through the link, O. By this arrangement of the brake it is well protected from injury while at work, the connections are short and direct, and the strains of its action are self-contained in a single part of the machine, and not transmitted from one part through others to another part, with a powerful tendency to separate them at every stroke as heretofore.

The friction surfaces of the bar and guide are likewise effectually protected from any fouling action from the gun, which has been a source of much trouble in other machines, especially in damp weather when the brake would not hold well. The adoption of the light T iron brake-bar, instead of the angle iron heretofore used, affords the requisite strength with less weight, admits of a simpler and shorter pin connection with the ends of the brake arms, and thereby permits the use of as small as nine inch channel iron for uprights; and at the same time it allows sufficient room between the flanges for the use of a six inch brake-arm, while the small flat friction surface has proved to be as effective as the more extended V of the angle iron.

The axes of the gun and ram project two inches from the face of the guides, in order to give sufficient clearance to the cross-bars when driving crooked piles, but this overhang has not proved detrimental to the action or efficiency of the machine in any respect.

To facilitate the tool dressing and accurate fitting of the jaws of the gun and ram to this particular sectional form of guides, wrought iron plates, P and Q, are bolted to their wings, or arms, to form the inside lips of the jaws, as shown.

The plates, P, of the ram, against which the brake bar bears, are made a little thicker than those of the gun, so that the brake can be applied to the ram only, and they are also notched into the arm a little to resist the shearing strains due to the instantaneous change of motion while in operation, it having been found difficult heretofore to securely bolt anything of any magnitude to the ram. The sills of the framing are of wood and rest upon the long rollers ordinarily used on land machines to facilitate its movement. The diagonal angle and bar iron braces, R, S and T, are merely to give additional stiffness to the framing.

The principle of its action, and manner of operation, do not differ from the original form of construction.

The only advantage or improvement claimed is in the overcoming many of the mechanical difficulties which have been in the way of producing a much lighter and cheaper machine, consistent with the requisite strength, efficiency and durability.

Ordinary rolled iron has, therefore, been largely used in its construction, it possessing all the necessary qualities afforded by McHaffie steel for this purpose at less than half its cost per pound, and with somewhat less weight. Moreover the uprights can be made in a continuous piece, without any joints or bolts incident to the use of cast iron or steel in sections, and, unlike them also, the guides require no machine fitting or tool dressing, while its superiority over cast iron in every essential respect is sufficiently obvious without further comment.

By this plan a saving of about 25 per cent. in cost of construction is effected, as well as a reduction in weight, over the best machines hitherto made, while its operation has been most satisfactorily tested.

It will be observed that the jaws of the ram and gun literally grasp this form of guides, forming a bearing on each of their four faces, so that the uprights support each other; all side thrusts or strains in either direction being thus communicated to them both and borne in common.

By the use of a preferred form of channel iron for the uprights (shown at X, on sheet 2, but which was not so readily obtainable at the time) having shorter and thicker flanges for guides, it is presumed that the necessary groove to fit the guides can be planed in the jaws out of the solid, and perhaps cored with sufficient accuracy to obviate the necessity of fitting any plates, or even of any tool dressing, which would still further simplify and reduce the cost of construction.

To facilitate its being taken apart for transportation, the side bars are only bolted in place, and by their removal the frame is readily taken down.

The following data has been tabulated from records of work done by this process in the writer's experience at League Island :—

No. of record.	CLASS OF WORK.	DESCRIPTION OF MACHINE.	No. of Piles Driven.	Diameter of Piles. Inches.						Distance Driven. Feet.			No. of Blows per Pile.			Weight of Powder per Pile. Pounds.			Weight of ram. Pounds.	Bore of Gun. Inches.
				Top.			Bottom.			Feet.			Pile.			Pounds.				
				Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.		
1	Landing wharf.	Cast iron frame.	811	19	10.5	13.1	13.6	8.7	22.5	14	19.4	19	3	5.2	1.3	1/4	1/2	1300	6 1/4	*
2	Foundat'ns for store-house, etc.	Wood and iron combined.	966	15	10	12	11.6	5.8	30	21	24			20			2	1200	5 3/4	†
3	Foundat'ns for iron plating shop.	Same machine.	457	19	9	12.2	14.7	5.8	7.36	20	29.2	85	11	30.4	9 1/4	1 1/4	3 3/4	1700	6 3/4	‡
4	"	Same machine with lighter ram	63	16	10	12.7	12.7	5.9	31	25	29.5	122	39	59	6.15	4	6 1/2	1200	5 3/4	‡
5	"	Wrought iron frame.	172	17.5	9	11.4	12.7	8.3	32.5	26	29.2	30	6	12.7	4 7/8	1	3.2	2170	7 1/2	‡

* Machine on scow and operated afloat. The first machine employed upon actual work. Piles of heavy yellow pine, and driven through mud, containing clay, to compact gravel.

† Machine operated on land. Piles of hemlock and firmly driven, without pointing, through stiff clayey material mixed with sand, to hard gravel and boulders. Number of blows and weight of powder per pile, approximate.

‡ Machine operated on land and piles of hemlock. Materials, same as No. 2, and in addition overlaid with from 4 to 9 feet of tolerably dry filling, consisting of mud clay, sand and gravel. The wrought iron machine completed this work.

This wrought iron machine was only recently finished, and put in service on the work in hand just before its completion, and the piles driven were placed in clusters of 13 each, spaced 21 feet apart instead of continuous rows.

By carefully comparing data of Nos. 3, 4 and 5 with each other, a great difference will be observed in the number of blows and quantity of powder used per pile, in the employment of differently proportioned machines upon the same work, the ram and plunger of No. 4 being altogether too light and small for its work. A still heavier ram than Nos. 3 or 5, with a proportionate increase of calibre of gun, would doubtless perform the same work with less number of blows and less expenditure of powder; or, in other words, with greater rapidity and economy. Hence the necessity of adapting these ma-

achines in point of capacity to the work upon which they are employed, in order to attain the best results.

It is to be regretted that no reliable data as to actual cost of operation has been obtained.

The work mentioned has been done by contract, and the limited supply of piles to the machines did not permit their constant use without interruption scarcely for a day at a time, the force employed to operate them having been too small to also keep them supplied with piles at the same time. Under favorable circumstances, however, as many as 81 piles have been driven in $9\frac{1}{2}$ hours, and 12 in a single hour. The actual time required to do the work of driving alone usually varied from three-fourths to one and a half minutes.

The character of the work done, in which the chief interest was felt and to which particular attention was directed, has been very satisfactory and far superior in every respect to that done by impact by the ordinary process.

For the work of Nos. 3 and 4, the machine was too short to receive piles of sufficient length to reach the hard bottom without resorting to punching.

By this means, however, and to which this process is admirably adapted, much shorter piles were used, and a saving of material effected, as the pile heads had to be cut off at half tide level.

January 12th, 1874.

DETROIT RIVER TUNNEL.*

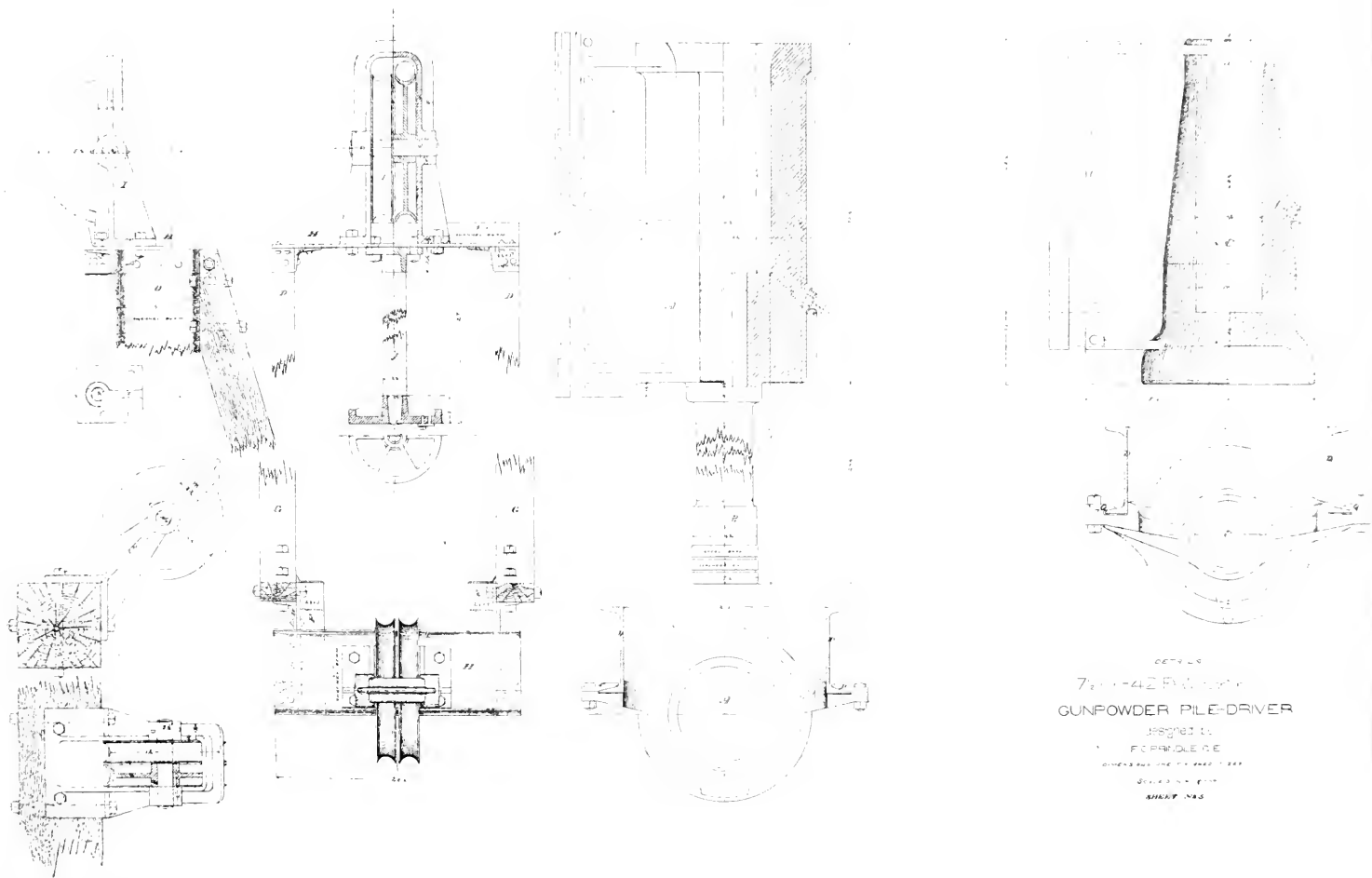
BY E. S. CHESBROUGH, C. E.

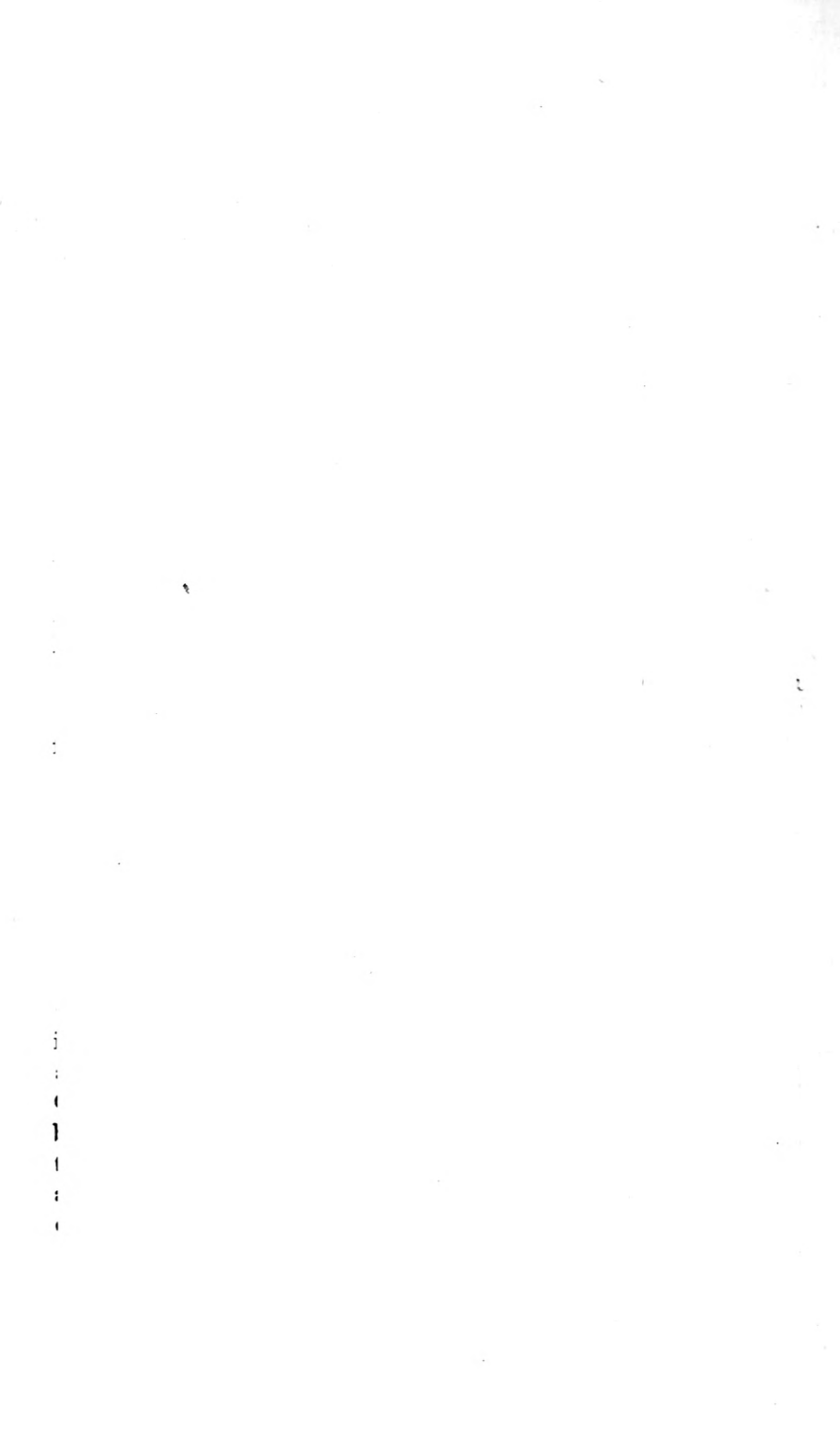
A Paper read at the Fifth Annual Convention, in Louisville, Ky., May 21st and 22d, 1873.

At the date of the former paper† on this subject, read at the last Convention, the preliminary work on the Detroit River Tunnel was in a very encouraging state. The Detroit shaft had been sunk, and a drainage tunnel extended from it for about 600 feet toward the Canada end. The Windsor shore shaft had been sunk to below the bottom of the drainage tunnel, which had progressed about 100 feet toward the Detroit end. With the exception of finding harder ground, and consequently making slower progress than had been originally expected, the prospect of a successful completion of the work was

* LX Transactions of the American Society of Civil Engineers, Nov., 1873.

† XLII Transactions of the American Society of Civil Engineers.





brighter than at its inception, since previous to sinking the Detroit shaft there was a fear that very troublesome veins of water, supplied from the land and having a higher source than the river, might be met. For this reason the Detroit shaft was sunk first, as the borings on the Windsor side did not indicate such veins of water.

In the latter part of July, 1872, when the work on the Windsor end had progressed about 250 feet through, for the most part, very hard ground, some of which was blasted, a sudden irruption of sand and water occurred, which threatened to fill the tunnel out to the sump, and choke the pumps. To prevent this, a bulkhead was constructed near the face, but before it could be made sufficiently tight the workmen had to retreat some distance to make an apparently successful stand, and even this did not prove sufficient, so that a third and last bulkhead, still nearer the shaft, was put in. This state of things looked very discouraging, and it was, of course, impossible to tell the exact nature and extent of the source of the irruption, or how long it would continue. From the character of the water itself, as well as from other circumstances, it evidently did not come from the river, and there was reason to hope its flow would soon diminish. This hope was not disappointed, and about the 14th of August the face was again reached, the bulkhead (and 150 cubic yards of sand) having been removed. Regular operations were resumed, but after 30 feet of new tunnel had been built a fresh irruption of sand and water occurred, making it again necessary to put in bulkheads, and preventing further advance for four days more. By this time it was concluded that the source of the irruption must be a vein, and not merely a pocket of sand; still it was hoped that it might prove quite limited in extent, and soon be passed. On the 12th of September, after the work had been extended 47 feet further, a third irruption occurred. After another placing and removing of bulkheads, and taking out of sand, causing a delay of five days, regular operations were resumed, and 10 feet advance made, when a fourth irruption occurred.

By this time the contractors had become very much discouraged, and felt that to continue the drift on the same level would be ruinous to them, as the work was costing more than four times the price they received for it. Inasmuch as the work on the Detroit side had been extended about 1200 feet—sufficiently far to drain the lowest portion of the main tunnel—and as the principal object now remaining was to explore the ground through which the main tunnel was to be built, it

was decided to make a "lift-shaft" at the end of the drift on the Windsor side, and get into the ground through which it was proposed to construct the main work, thus avoiding, if possible, the irruptions which had become so troublesome. This was accordingly done, and a new drift started at a level 10 feet higher than that of the drainage tunnel. The ground was much easier to excavate, but the irruptions, which formerly came from the top of the excavation, now came up through the bottom, there being a vein of sand at the level of the top of the lower drift. This was not a quicksand, nor usually running, and was only brought in, when it did come, by the force of running water. On reaching a point about 370 feet from the shore shaft, an irruption occurred, which continued so long that it seemed as if further progress in that direction was impracticable, in so small a drift, with the ordinary means of tunneling.

Before describing the further steps taken at this end of the tunnel, it will be well to mention what had been encountered and done on the Detroit side. The work was carried on there without any serious difficulty, and at a satisfactory rate of speed, until a point 1110 feet from the shaft was reached. There the quantity of water coming from the bed-rock, immediately beneath, increased considerably. Gas had been more or less troublesome most of the way, sometimes making the men's eyes so sore that they had to quit work for awhile. When a distance of about 1180 feet had been reached the machinery for ventilating the tunnel proved inadequate, and some delay was occasioned by having to put in more. Before the ventilating apparatus was started again, a man went out to the end of the work, and returned without having been injuriously affected by the air, which he said was bad. He reported a sand leak at the face. Two others then went out to stop the leak, which they expected to do in a few minutes; but they never returned alive. When they had remained as long as was thought necessary and did not return, the foreman sent a man to order them back, if their eyes were affected by the gas. He returned and said that they were dead. Others went in for them, but were unable to get them out alive, although one of them showed signs of life when first reached. (It was only after several attempts, and at great risk, that their bodies were recovered.) Previous to this no one connected with the work had feared any fatal results from inhaling the gas, the greatest evil apprehended being sore eyes.

After the new ventilating apparatus was set in motion, regular operations were resumed, and the work was extended to a point 1220 ft.

from the shaft. The influx of water here became so great as to require more powerful pumping machinery. It was thought best, however, not to require the contractors to incur this expense at the time, but to let them suspend work at this end until further developments were made at the Windsor side, where the prospect, as previously stated, was so discouraging.

At this juncture the contractors requested to be relieved from all further obligation to prosecute work under their contract, which the directors agreed to, on conditions not necessary to mention here.

It was then determined to carry on the work at the Windsor end by the day, by means of two parallel trial drifts, and to begin the second one at the shore shaft, at a level 10 feet above the grade of the drainage tunnel, leaving the latter to be used as a sand-holder in case of further irruptions. Thus it was hoped that, in either one or the other of the parallel drifts, some progress might be constantly made; experience having shown that a stream of sand and water flowing into the tunnel at one point would never be accompanied by a troublesome one flowing in at another. In fact, it was observed that water which flowed from an orifice which at first discharged sand as well as water, ceased flowing either shortly before or just when a new irruption occurred at the face.

The upper drift, for a distance of about 380 feet from the shore shaft, was easily constructed, in some cases upwards of 20 feet of progress being made in 24 hours. This drift was continued to the right of the old one, beyond the lift-shaft, and no irruption occurred in it until an advance of about 20 feet was made beyond the face of the old or first drift. Then an irruption occurred, and the water and sand ceased flowing into the old drift, which was extended 50 feet before the water returned to it and left the new one free. The latter was in turn extended about the same distance, when the water changed over to it. Thus the work was carried on alternately in the old and new drifts, when the directors, becoming discouraged at its slow progress and excessive cost, ordered it stopped. The actual advance in new ground during the last two months was only 64 feet, and the cost about \$7500, or more than $6\frac{1}{2}$ times the contract price.

Besides the discouragements connected with the work, the unusual severity of last winter caused such an interruption in the movement of freight across the river at Detroit, as to amount almost to "strangulation," certain and speedy relief from which was felt to be an absolute necessity; otherwise the already very heavy and constantly

increasing business of the two railways interested must be largely diverted to other channels.

The decided refusal of the Canadian Parliament, a few years since, to grant a bridge charter has been succeeded recently by the granting of one to a company whose road crosses a few miles below Detroit, on condition that Congress shall grant one also. The matter is now the subject of investigation by United States Engineers, who are to report before the next meeting of Congress.

While the construction of the Detroit tunnel, as a simple engineering problem, cannot seem otherwise than practicable to the members of the profession, especially in the light of the experience gained on the Thames tunnel, and similar works completed since, the advisability of constructing it, as a judicious expenditure of money, was left to be fully settled by the making of the drainage tunnel. The engineer believed, from the original borings, and from the earlier operations on the drainage tunnel, that the main work was not only practicable but advisable; later developments, however, throw much doubt upon its advisability.

It remains to answer several questions which will very naturally occur to members of the Society, such as—

1st. Why was not the character of the veins of sand, which gave so much trouble, revealed by the borings made before the work was begun?

The borings did frequently pass through small deposits of sand, but pockets of this material are so common in drift clay, that nothing is thought of them in ordinary tunneling. As already mentioned, fears were entertained that trouble from a great influx of water might be encountered in the Detroit end, but no such difficulty occurred there.

2d. Why could not the orifices through which the irruptions occurred be stopped?

This experiment was tried several times, but it always ended in making matters worse instead of better. If the influx was stopped at one point, it broke out at another. If the whole face was completely protected against it, the fresh joints in the masonry would be washed out. This will not be wondered at when it is stated that the source of the in-pressing water was ascertained, after the stoppage of the work, to be more than 100 feet above the bottom of the drainage tunnel.

3d. Why could not a shield have been used to advantage?

This was thought of, but experience, both in Chicago and elsewhere, had shown that shields, in such small drifts, through soft clay, are exceedingly difficult to keep in line. Such would have been especially the case on this work, where, after each irruption, the end of the masonry and, toward the last, the timbering, were so twisted and broken, laterally and vertically, as to require rebuilding in several instances.

4th. Could not the work have been carried on by the pneumatic process?

Besides the fact that no horizontal drift of any length is known to have been made in this manner, it will be sufficient to state, to those familiar with this process, that work executed under a pressure equal to 90 or 100 feet head of water is not only very expensive, but hazardous to human life.

Another reason for not excluding the sand permanently, if it could be done, was that by letting it come in till it ceased to flow of itself, the ground would be left in a much better state for the main work. This belief was confirmed by making the second and parallel drift, in which no irruption occurred until after all the old ground worked in had been passed.

A MEMBER—How was it ascertained that the source of the water was 100 feet higher than the tunnel?

MR. CHESBROUGH—The top of the shore shafts are 106 feet above the top of the drainage tunnel; after the work ceased entirely, the shaft was allowed to fill up, when the water rose to the top, and now flows over.

MR. McALPINE—It is stated that the inflow of the water in these tunnels evidently came, not from the river, but from a higher source. When building the dry docks at Brooklyn, precisely the same result took place. We were 40 feet below the level of tide-water, and fresh water came in with a head of 50 feet—perhaps 100 feet—higher than that of the salt water.

MR. C. SHALER SMITH—Did this irruption come from below?

MR. CHESBROUGH—I am sorry I have not a section here. I am satisfied that it came from below. There was a vein of sand just above the top of the drainage tunnel, and when there was an irruption it seemed to come from that. The irruptions at first were rather from above, then we went up and obtained a rock grade on the Windsor end, and *there* the water pressed upward, and I think it came from the rock. I will give you another reason: At a place called Sand-

wich, below Detroit, where there are sulphur springs, the water frequently rises 30 or 40 feet above the river.

MR. C. SHALER SMITH—Almost the same circumstance happened in sinking one of the piers of the St. Charles Bridge by the pneumatic process. At about 50 feet below the surface, a sulphur spring was struck, which, from the manner in which the water rose in the caisson, had evidently a greater head than the river above it.

MR. CHESBROUGH—I have heard of several instances like that.

MR. BOLLER—You spoke of sulphur springs in the neighborhood, and suppose that the water which came in on you had a similar source; was it sulphur water?

MR. CHESBROUGH—Yes, sir; it was.

TRIAL OF THE WORTHINGTON PUMPING ENGINE, AT PHŒNIX-VILLE, PA.

Editor of Journal of Franklin Institute:

DEAR SIR,—I send you a report of the trial of the new Worthington pumping engine just completed for the water-works at Phœnixville, Pa., forwarded me with other data by Mr. Robert Davies, one of the water-works committee of trial.

You will see that the duty of the engine was 70,422,306 lbs. of water raised one foot by 100 lbs. of coal.

This is much higher than that produced on the trial of the Belmont W. W. engine, and reported in the Journal of February, 1873, when the duty was given as 54 millions by one method (the actual duty) and 63 millions, calculated on a basis of $9\frac{1}{2}$ lbs. of water per lb. of combustible.

The Phœnixville engine is one of Mr. Worthington's new style; one pump is worked by a high-pressure cylinder which exhausts into a tank; the steam from this tank works a low-pressure cylinder, which operates the other pump.

The indicator cards show that no expansion takes place in the cylinders, and yet the engine shows very great economy per lb. of coal; how much of this is due to the engine, and how much to the boiler, we have no means of knowing. The indicator cards show 16 H. P. for the high-pressure cylinder, and 23 H. P. for the low-pressure. Total, 39 I. H. P., or one I. H. P. per 2.44 lbs. of coal.

The actual or effective H. P. from water lifted was accomplished by 2.8 lbs. of coal.

The only exception which can be made by any one, would be that the trial, five hours, was too short. The *effective value* of the fire remaining at the end of a trial is a matter of judgment; Mr. Davies is of the opinion that the fire was better than at the commencement; and the same fire did actually run the pumps up to speed one hour after the official trial had ceased.

When we look at the facts, of the small dimensions of the engine; that it was fired by the regular fireman, and from the usual coal pile, and no deductions made for ashes and refuse, the result is very satisfactory. Deducting for ashes would make it little over two lbs. of coal per I. H. P.

Engineers who have given all their attention to short cut-offs and great expansion may find other roads to economy.

Subjoined please find the report referred to.

Yours, truly,

EDW'D BROWN.

Philadelphia, Dec. 22d, 1874.

TO THE BURGESS AND TOWN COUNCIL OF THE

BOROUGH OF PHOENIXVILLE:

Gentlemen,—The undersigned, a committee appointed by your honorable body to test the capacity and duty of the Compound Horizontal Duplex Pumping Engine and Pumps, built by H. R. Worthington, of New York, for service at the Water Works in this Borough, beg leave respectfully to report—That in the performance of their duty as said committee, they met at the engine house of said water works, on Tuesday, December 2d, 1873, and there, in connection with Mr. Frank W. Jenkins, who represented the maker of the engine and pumps, proceeded to make the trial.

As your committee are informed, no fire had been under the boiler for three days previous to the trial; that the fire was only started under the boiler about 7 o'clock on the morning of the trial; consequently the walls surrounding the boiler were cold, and it was not until 10 o'clock that the steam was in condition to begin the trial. At exactly 10 o'clock, A. M., the trial was begun, and it was continued for exactly six hours. All the coal used was weighed either by or in the presence of one or more of your committee, the condition and thickness of fire, the quantity of water in the boiler, and the pressure of steam, were all carefully noted at the beginning and end of the trial, and your committee are satisfied that the fire was better and of as great thickness at the end of the trial as at the beginning; the depth

of water was $\frac{1}{4}$ inch in excess of that at starting, and the steam pressure 3 pounds per square inch greater.

Observations were made by your committee at each half hour during the trial, making in all thirteen observations as follows :

Time of Observation.	Pressure of Steam by gauge.		Vacuum by gauge.		Register of counter.		No. of strokes since last registration.	Strokes per minute, by count.	Water pressure by gauge.	Length of stroke of pump.	Amount of coal consumed.		Water in boiler gauge.	Height of water pressure gauge above water in well.	
	Boiler.	Eng. room.									Inches.	Lbs.		Ft.	In.
10 A. M.	47	43	27 $\frac{3}{4}$	185136		41	73	24 $\frac{1}{2}$					13 $\frac{3}{4}$	13.	3 $\frac{3}{4}$
10.30 "	47	43 $\frac{1}{2}$	27 $\frac{3}{4}$	185507	371	48	73	24 $\frac{1}{2}$					13 $\frac{3}{4}$	"	"
11 "	48	45	27 $\frac{1}{2}$	185862	355	52	73 $\frac{1}{4}$	24 $\frac{1}{4}$					13 $\frac{3}{4}$	"	"
11.30 "	48	45	26 $\frac{3}{4}$	186236	374	50	73	24 $\frac{1}{2}$					13 $\frac{3}{4}$	13.	4 $\frac{3}{4}$
12 M.	48	45	26 $\frac{3}{4}$	186608	372	49	73	24 $\frac{1}{2}$					13 $\frac{3}{4}$	"	"
12.30 P. M.	50	47	26 $\frac{1}{4}$	186996	388	53	73 $\frac{1}{4}$	24 $\frac{1}{4}$					13 $\frac{3}{4}$	"	"
1 "	50	47	26 $\frac{1}{4}$	187405	409	54	73 $\frac{1}{4}$	24 $\frac{1}{4}$					13 $\frac{3}{4}$	"	"
1.30 "	50	47	26 $\frac{1}{4}$	187809	404	54	73 $\frac{1}{2}$	24 $\frac{1}{2}$					13 $\frac{3}{4}$	"	"
2 "	49 $\frac{1}{2}$	46 $\frac{1}{2}$	26 $\frac{1}{2}$	188212	403	54	73 $\frac{3}{4}$	24 $\frac{1}{4}$					13 $\frac{3}{4}$	"	"
2.30 "	49 $\frac{1}{2}$	46 $\frac{1}{2}$	26 $\frac{1}{2}$	188612	400	52	73 $\frac{3}{4}$	24 $\frac{1}{4}$					13 $\frac{3}{4}$	"	"
3 "	50	47	26 $\frac{3}{4}$	189028	416	52	73 $\frac{1}{2}$	24 $\frac{1}{2}$					13 $\frac{3}{4}$	"	"
3.30 "	52	49	26 $\frac{3}{4}$	189430	402	54	73 $\frac{3}{4}$	24 $\frac{1}{4}$					13 $\frac{3}{4}$	13.	5 $\frac{1}{4}$
4 "	50	47	26 $\frac{3}{4}$	189831	401	54	74	24 $\frac{1}{4}$	570		2		13.	13.	5 $\frac{1}{2}$

Number of revolutions of the pumps during the trial, 4695 ; average stroke of pumps, $24\frac{3}{16}$; number of pounds of coal used on trial, 570 ; capacity of pumps per revolution, 54,240 gallons, at two feet stroke. Number of revolutions equated to two feet stroke,

$$\frac{4695 \times 24 \cdot 3 \cdot 16}{24} = \frac{113560}{24} = 4731 \times 54 \cdot 24 = 256,609$$

gallons discharged. Average distance of water below gauge, 13 feet $4\frac{3}{4}$ in. Pressure of gauge average, 73.384 pounds. Height equal to a pound in column of water of one square inch, 27.70 inches nearly, then

$$\frac{73 \cdot 384 \times 27 \cdot 70 \div 13 \text{ ft. } 4\frac{3}{4} \text{ in.} \times 12}{12} = \text{height lifted in feet } 182 \cdot 79.$$

12

Actual difference in level between the water in the Schuylkill at the pump, and the average level in the water basin during the pumping was 185.59 feet, showing a variation against the pump of 2.80 feet, in addition to any friction in the pipes, probably not less than two feet additional.

Quantity of water pumped during the trial as determined by the measurements at basin before and after the trial, was 258,316 gallons.

By the contract with H. R. Worthington, the maker of the pump, its capacity was to be equal to the supply to the basin as located of 1,000,000 of gallons of water in 24 hours, and its duty was to be 45,000,000 pounds of water raised one foot high with the consumption of 100 pounds of coal.

One gallon of water weighs 8.3388 pounds.

By the above data it will be seen that the capacity was

$$\frac{226,609 \times 24}{6} = 1,626,436 \text{ gallons in 24 hours.}$$

The pumps actually raised as per mode of measurement provided for in the contract, 256,609 gallons, weighing 8.3388 pounds per gallon, = 2,139,811 pounds 182.79 feet high = 391,136,052 pounds 1 foot high.

As this work was done with the consumption of 570 pounds of coal, the equation becomes

$$\frac{391,136,052 \times 100}{570} = 68,620,360 \text{ pounds of water lifted 1 foot with}$$

100 pounds of coal, or the whole put in the equation as per contract

$$\frac{227882 \times 2 \times 4695 \times 182.79 \times 100}{570} = 68,620,360 \text{ pounds, the}$$

contract calling for but 45,000,000.

The fire remaining after the trial actually ran the pumps up to contract speed for one hour, the pumps making in the time 7658 revolutions and elevating to the reservoir nearly 42,000 gallons of water, or at the rate of 1,008,000 gallons in 24 hours, showing that the fire was not exhausted during the test.

In this connection your committee take much pleasure in stating that in their opinion Mr. Worthington not only carried out the letter, but the spirit of the contract in furnishing the pumping apparatus above referred to; the whole seems perfect in all its parts, the mechanical details appear to be unexceptionable, leaving apparently nothing to be desired in the way of improvement or addition to make it more complete.

It will be seen from our report that to pump 1,000,000 gallons in 24 hours only requires a speed of piston of about 51 feet, while the

pumps will run easily 75 feet per minute, and would perform reasonably well even up to a speed of 90 feet per minute, or over 75 per cent. in excess of the trial speed, but your committee think it would not be advisable to run the pumps over 50 per cent. in excess of the trial speed. In other words, they think the limit of capacity of the pumps would be reached at about 1,500,000 gallons in 24 hours.

Your committee think it but fair to state, that they believe Mr. Worthington entitled to the actual height pumped, with the addition of two feet for friction, which will give an actual duty of

$$68,620,360 \times 187.59$$

$$182.79 = 70,422,306 \text{ pounds of water raised one foot}$$

with 100 pounds of coal.

The measurements made at the basin were made with much care, and were intended to check the work of the pumps, and your committee are free to say that, from the very large duty shown, they would have been inclined to doubt whether there had not been some leakage at the pumps; as it is, they have no hesitation in saying that they have no doubt the actual quantity of water registered was forced into the reservoir on the trial.

The coal used on the trial was taken without selection from the supply on hand which was provided for general use.

Respectfully submitted,

JOHN GRIFFEN,	} <i>Committee.</i>
GEORGE WALTERS,	
ROBT. H. DAVIES,	

NOTE —The plunger of high pressure pump is 12 inches, and the piston rod $2\frac{1}{2}$ inches in diameter.

The plunger of low pressure pump is 14 inches and the piston rod three inches in diameter. Which give the capacity per revolution of both pumps 54.24 gallons; the stroke being two feet.

NOTE RELATIVE TO THE ESTIMATION OF THE COMMERCIAL VALUE OF COALS CONTAINING LARGE QUANTITIES OF ASH.

BY PROF. R. H. THURSTON.*

A question has lately been presented, involving the determination of the effects of an excessive amount of ash in modifying the commercial value of anthracite coal. The method of determination adopted will probably be of interest, since there is at present no generally accepted and standard method in use among engineers.

The value of a coal depends upon many circumstances. The proportions of uncombined carbon and hydrogen, the form in which hydrocarbons are contained in the fuel, the physical characteristics of the coal, and the chemical constitution and the percentage of the ash, all affect its market value. In individual cases, also, the form of heating or other apparatus in which the coal is burned influences the relative value of fuels equally good in other respects, one steam boiler, for example, being well adapted for anthracite, and another for bituminous coal.

Where the difference between two coals lies principally in their relative percentages of ash, the comparison is easily made.

The anthracites contain so little other combustible matter that, as shown by Professor Johnson,† their calorific value is proportional to the percentage of contained carbon, very nearly. Their commercial value is somewhat different.

The depreciation produced by presence of non-combustible matter occurs in the following ways :

First. A certain amount of carbon is required to heat the whole mass to the temperature of the furnace, of which a large part is lost. It follows, therefore, that a coal containing a certain small quantity of combustible would have no calorific value, and, consequently, would be worthless in the market.

Second. The presence of a high percentage of ash in a fuel checks combustion by its mechanical mixture with the combustible portion of the coal. A coal will, hence, have no commercial value when the proportion of refuse reaches a limit at which combustion becomes impossible in consequence of this action.

Third. The cost of transportation of ash being as great as that of transporting the combustible, the consumer paying for ash at the

* From Scientific American (communicated by the Author.)

† Report to the Navy Department on American coals.

same rate as for carbon, and also being compelled to go to additional expense for the removal of ash, these facts would also determine a limit beyond which an increased proportion of ash would render the fuel valueless.

Fourth. The determination of the financial losses due to increased wear and tear of furnaces and boilers, of incidental losses due to inequality or insufficiency of heat supply, and to the many other direct and indirect charges to be made against a poor fuel, will also indicate a limit which will have a different value for each case; but which will, in most cases, be difficult of even approximate determination.

The determination of the minimum proportion of combustible, under the first case, is thus made, assuming this heat to be entirely wasted.

The specific heat of ash is usually nearly 0.20. Let X represent the percentage of ash which is sufficient to render the coal valueless. Then, since each pound of carbon has a heating power of 14,500 thermal units: $14,500 (100 - X) = A$, represents the available heat of a unit in weight of the fuel.

$100 \times 0.20 \times 3,000^\circ = B$; represents the heat required to raise this same amount of coal to a temperature equal to that of the furnace, which is here assumed at $3,000^\circ$ above the surrounding atmosphere.

Since these quantities, A and B , are equal: $14,500 (100 - X) = 100 \times 0.2 \times 3,000$, and $X = 96$ per cent.

The minimum quantity of fuel permissible is, therefore, four per cent. where the first consideration only is taken into the account.

The influence of the second is at present indeterminable in the absence of experiment.

The cost of transportation of ash to the consumer, as a part of the fuel, has no bearing in the determination of its value to him. The removal of ash is a tax upon the consumer which may be considered as the equivalent of the loss of a certain weight of combustible received. Since this cost fluctuates with the market value of coal, and since its amount is determined by the same causes, it is easy to make the statement in that form.

This cost is about ten per cent. of the value of coal, weight for weight, and is therefore assumed at ten per cent. of the proportion of ash found in the coal.

The losses, direct and indirect, coming under the fourth head, vary

greatly and are sometimes very serious. An approximate estimate for an average example is taken, and is considered to be equal, at least, to a percentage of the total value of coal, in utilizable carbon, which equals one half the percentage of ash.

Comparing two anthracites, which we will suppose to contain, respectively, fifteen and twenty-five per cent. ash, eighty-five and seventy-five per cent. carbon, the first being a well-known standard coal, selling in the market at six dollars per ton, we may, using this system of charging losses against equivalent values in combustible carbon, determine the proper commercial value of the second kind.

FIRST EXAMPLE.—From the 85 per cent. carbon :

Deduct for heating to furnace temperature,	0.040
“ transportation of refuse, 10 per cent. of 15,	0.015
“ other losses, 50 per cent. of 15,	0.075
	<hr/>
Total,	0.130

Leaving available and valuable carbon $85 - 13 = 72$ per cent.

SECOND EXAMPLE.—From the 75 per cent. carbon :

Deduct for heating to furnace temperature,	0.040
“ removal of ash, 10 per cent. of 25,	0.025
“ sundry losses, 50 per cent. of 25,	0.215
	<hr/>
Total,	0.190

Leaving valuable available carbon $75 - 19 = 56$ per cent.

Finally, if \$6.00 is paid for 72 per cent. available combustible, for 56 per cent. we should pay $\frac{56 \times 6}{72} = \$4.66\frac{2}{3}$.

Taking a third example, in which the fuel contains the unexceptionally large proportion of 30 per cent. ash, we should, by similar method, proceed as follows, deducting from the seventy per cent. carbon, as before, the estimated charges against it.

THIRD EXAMPLE :

Deduct for heating,	0.040
“ removal of ash, 10 per cent. of 30,	0.030
“ sundry expenses, 50 per cent. of 30,	0.150
	<hr/>
Total,	0.220

Leaving available carbon, $70 - 22 = 48$ per cent., which would be worth $\frac{48 \times 6}{72} = \4.00 .

Had the first coal had a market value of seven dollars per ton, the second and third would have been worth, respectively, \$5.44½ and \$4.66⅔.

This method is evidently largely empirical, and its results are but approximate. It is, however, simple and easily applied, and will often be found of use in the absence of more precise means of determination. Those whose experience may differ from that of the writer can readily modify the values for themselves.

Steven's Institute of Technology, Hoboken, N. J., December, 1873.

Reduction of Silver Salts by Hydrogen.—Dr. Russell, F. R. S., communicates the fact to the Chemical Society, that thoroughly washed and purified hydrogen causes a precipitation of metallic silver from a solution of silver nitrate, the precipitation occurring much more readily in saturated than in dilute solutions. The gas employed was usually procured by the action of a saturated solution of copper sulphate on zinc, or by the action of water on powdered zinc and tin. After it has passed for about half an hour through a saturated solution of the silver salt, a dull greyish deposit is produced, which is succeeded by a bright crystalline deposit. A clear solution, through which hydrogen had been passed, became turbid and gave a precipitate of silver when heated. Similar effects were obtained when the solution was exposed to an atmosphere of hydrogen instead of causing the gas to bubble through it. The author has conclusively proved that these phenomena are caused by the hydrogen replacing the silver in the silver nitrate, producing hydric nitrate. But a secondary reaction also takes place between the nitric acid and the precipitated silver, which results in the formation of silver nitrate. Dilute solutions of nitric acid have little or no action on silver, as hydrogen precipitates silver as readily from a nitric acid solution as from an aqueous solution. It has long been well known that hydrogen will precipitate from their solutions the platinum metals and gold, and the above observations with regard to silver add to its importance as a reducing agent.

Chemistry, Physics, Technology, etc.

ON ARTIFICIAL FUEL.

A paper read before the Franklin Institute, at the stated meeting, January 21, 1874.

By E. F. LOISEAU.

It is so evident that great advantages would be gained by coal operators, and by the public generally, from the utilization of what is known as *coal dust*, *sluck*, *waste*, or *culm*, that it is to be wondered that manufactories to transform this worthless material into a marketable fuel are not erected everywhere in the mining regions. The immense accumulations of coal-waste to be found in those regions are really a nuisance to the inhabitants and an eye-sore to the traveling public.

It is generally admitted that, on an average, from 40 to 50 per cent. of the entire coal production, both in this country and in Europe, is converted into dust or waste, the amount of which will be in proportion to the brittleness of the mineral and to the different operations to which it is submitted, in order to classify it by sizes for the market.

The utilization of this waste has been a problem which scientific and practical minds have tried to solve for a number of years. Partial results have been obtained by which a certain amount of the waste of coal mines has been utilized, and this only in Europe, where a gradual and constant increase in the cost of the natural coal has given to the manufacturers of artificial fuel a fair chance of profit, but it must be admitted that, compared with other branches of industry, the progress made in the utilization of coal waste has been very slow. The enormous increase in the cost of coal in England, France, Germany and Belgium during the last three years, has, however, brought again before the public, and this time prominently, the question of utilizing the waste created everywhere that coal is handled. The question, then, at the present day, which concerns the manufacture of artificial fuel, as we call it, or of patent fuel or agglomerated coal, as it is called in Europe, is not one of prejudice, but of necessity, for the waste of the coal resources, both in this country and abroad, has at last assumed such gigantic proportions, that some efficient means must be found for the economical utilization of the small coal which is now unavoidably made, even under the very best known systems of working coal.

Bituminous coal dust will coke well, and it is much used for that purpose, but the demand for coke not being in any way equal to the supply of bituminous small coal from which it might be made, a great proportion of the latter is left underground, and ultimately becomes lost beyond all possibility of future recovery. A small proportion of bituminous slack is used by blacksmiths and even on peculiar grates for engineering purposes, but the largest part is, as said before, left underground, or thrown into rivers or piled up around the mines, occupying ground which might be better and more conveniently used for other purposes.

The waste created in the preparation of anthracite coal for the market is considered entirely worthless. It may be estimated that from 25 to 30 per cent. of the entire production of this coal is reduced to dust by the operation of the breaker alone. The vast, unsightly mounds of coal dust in the anthracite coal regions have become a familiar feature of Pennsylvania's landscape; they are increasing in number and in size every day, and it is estimated that the quantity of said waste exceeds to-day thirty millions of tons.

Although several establishments have been created in France, England and Belgium for the purpose of converting the coal waste into marketable fuel, that branch of industry is at present quite in its infancy. France has to day 28 and Belgium 9 manufactories of artificial fuel. In England, the principal seat of those manufactories is in South Wales, whence steam coal is shipped chiefly for foreign ports.

Coal dust can be manufactured into solid lumps in two different ways: by simple compression without the addition of any cementing material, or by agglomeration with cements.

In England, Messrs. Bessemer, Rees and Buckwell, and in France, Messrs Baroulier, Evrard and Loup have patented different processes for the compression of bituminous coal dust into solid lumps without cements. The coal manufactured had a great heating power, but it could not bear handling and transportation.

Bessemer, heating previously the bituminous slack until it was brought to a plastic state, forced it, by a piston, into a long tube whose diameter was gradually reduced and from which the compressed coal was forced in a continuous cylindrical shape. By means of a revolving knife, the fuel was cut in sections of any required length, as fast as it was forced out of the tube. This process required very powerful machinery. Bessemer was compelled to reduce gradually

the length of the tube and to increase its thickness, as it bursted very often. The process required a large amount of natural coal to heat the dust to a pasty mass, and while being heated, it eliminated from the coal the greatest part of its volatile constituents. The application of Bessemer's process has long ago been abandoned.

Buckwell and Evrard compressed the bituminous waste into moulds without heating it previously. Although a powerful pressure was applied to the fuel the product could not bear handling.

Baroulier used circular iron moulds of a certain depth, open on top and at the bottom. These moulds were filled with coal dust and this dust compressed by hydraulic pressure; more coal was then added, this again compressed, and so on, until the moulds were completely filled. The moulds were then placed, side by side, on an iron plate, in a car having perforated sides and bottoms; another plate was then placed over all the moulds and bolted to the one on which they rested; another series of moulds were placed side by side, on that second plate, covered by a third plate, securely bolted to the second one, and so on until the car was filled. This car was then taken to an oven heated to 400° Fahrenheit. The plates between the moulds prevented the expansion of the coal and the escape of the volatile matters contained in it. This process, although a real improvement on Bessemer's process, had some of its defects; it required much labor, a large quantity of moulds, plates, iron cars, etc., which had to be replaced very often, and it also consumed a large amount of coal. The expenses were so excessive that the manufactured fuel could not be sold in competition with the natural coal. The establishment erected by Mr. Baroulier at Gangreneuve, near St. Etienne, France, was in operation only two years, 1857 and 1858.

These are the only serious attempts which have been made to convert bituminous coal dust into solid fuel without cement. Rees took out an English patent for a process similar to Baroulier's. He did not meet with more success than my countryman did.

Among the numerous cements which have been patented for the manufacture of artificial fuel are to be found the strangest substances, such as *spoiled flour, blood, gum arabic, animal and vegetable oils, cow dung, rakings of roads, sweepings of houses, chalk, common salt, sal ammoniac, sulphur, solutions of glue, alkaline silicates, alum, copperas, etc., etc.* It is unnecessary to add that of these singular materials none have ever been brought into practical use.

Among the cements which have been used to a certain extent may

be cited *rosin, asphalte, petroleum, coal tar* and its derivative *fluid*, and *dry pitch, lime, plaster, starch* and *clay*.

Professor A. S. Bickmore, in a very interesting paper on "Coal in China," read before the American Association, says that "from time immemorial, in the north of China, coal is ground to dust and mixed with clay, that it may burn more slowly."

In 1603, a pamphlet entitled "A new, cheap and delicate fire of coal balls," was published in London by Sir Hugh Platt. This gentleman recommended for use in common fire-places, a mixture of coal and clay, moulded by hand in the shape of *balls*. He also used another mixture which consisted of coal dust, tanner's bark, sawdust and cow-dung. The preparation of the materials with water and the moulding of the composition into balls, by hand, is fully described in that pamphlet.

Another pamphlet, also published in London, in 1679, and entitled "An excellent invention to make a fire," contains the following recipe: "Take three parts of the best Newcastle coal, beaten small, one part of clay; mix these well together into a mass with water; make thereof balls, which you must dry very well. This fuel is durable, sweet, not offensive by reason of the smoke or cinder as other coal fires are, beautiful in shape, and not so costly as other fire, burns as well in a room even as charcoal."

In an article on the coal basin of Eschweiler, Mr. Clère, a French engineer of great reputation, states that "at Liège, (Belgium,) coal dust is mixed with clay, pressed by hand in the form of balls, dried in the sun and stored away for domestic use. That kind of fuel is there called *Hochets*. I can add to this, that even to this very day not only at Liege, but everywhere in Belgium, coal dust is used in the same manner.

There exists in Belgium a certain class of working women who earn a scanty living by converting the coal dust into solid fuel. They call at every house in front of which a load of coal dust has been dumped, offering their services. These poor creatures can be seen daily in the streets, always two or three together, each one of them pushing a wheelbarrow loaded with clay, in which stands a shovel. They try their best, if the house is occupied by people in easy circumstances, to obtain a little more than the price which is usually paid to them. As soon as the price is agreed upon, they go at work in earnest; the coal dust is shovelled all around so as to form a circular bed of about one foot in thickness. From 25 to 30 per cent. of clay is diluted

with water and sprinkled over the coal, which is well mixed with the clay by means of the shovels first. Then, putting on wooden shoes and slightly lifting their skirts, they commence to trample upon the coal, turning round the coal bed from the circumference to the centre, and back again from the centre to the circumference, following each other like ducks. When the whole surface of the coal bed has been trampled upon twice, the mixture is turned over with the shovel, and the trampling recommences. After five or six operations of the kind have been gone through, the coal and clay have been worked to a plastic mass. This is piled up in a heap, and, seating themselves on their wheelbarrows, these poor women proceed to compress the fuel in the shape of balls, by hand. These balls are then dried in the sun, after which they are ready for use.

This very primitive and original way of mixing and compressing coal dust into lumps has never been patented.

In some parts of Germany, the trampling on the coal is done by men on horseback. In the Rhine regions, the mixing of clay with coal is an affair of constant occurrence. Many a traveler has opened his eyes on seeing a bushel or two of clay dumped with every cart-load of coal, and carefully mixed in with it by the attendant coal-heaver. But he is still more surprised to see his servant gravely empty a pail of water into his coal-box, together with the morning's supply of fuel. The coal is mostly slack, and the fires do not burn well if the coal is dry.

At Ham-sur-sambre (Belgium), in 1859, under the direction of Mr. Darbois, machines, invented by Mr. David, a French engineer of merit, were erected for the purpose of manufacturing, by mechanical pressure, solid lumps from semi-anthracite coal dust, mixed with 15 per cent. of clay. With these machines, lumps of cylindrical shape were pressed, also cylindrical lumps with perforations half an inch in diameter, through the centre. These machines were very expensive, and their production was very limited. In 1861, they were replaced by cheaper and more productive machines, invented by Mr. Martin from Liege (Belgium). These machines, making egg-shaped lumps, met with more favor, as the product was very similar, to the lumps pressed by hand. Martin's press is still in operation at Ham-sur-sambre.

At Tamines-sur-sambre (Belgium), in 1862, under the direction of Mr. Cavenaile, the company of the "Charbonnages réunis de la Basse sambre" (united collieries of the low sambre), of which I was

at that time the general agent, erected also Martin's machines to convert the coal dust into egg-shaped lumps, by using 18 per cent. of clay as cement. Martin's press made only one lump at a time; its length was 6 inches, and its diameter in the centre 4 inches. The feeding was very defective. This little model gives you an idea of Martin's press. Two rollers, having on their periphery one-half of an egg-shaped mould, revolve in opposite directions. In a hopper, placed above the rollers, is thrown the coal dust and clay, previously worked into a plastic mass. It was expected, at first, that the mixture, by its own weight, would fall between the rollers; but it did not, and two men had to be employed to force the mixture between the rollers. These men, by means of pounders, would alternately pound the materials through the hopper, while a third one was shovelling the plastic composition into it. As this work was very fatiguing, the men had to rest every half hour, and were replaced by another set of men, who worked also half an hour and rested, while the first men resumed work, and so on. The last improvement in the feeding part was to place, in the centre of the hopper, a vertical screw to force the mixture down. It seems that in 1867 some more improvements were added and patented by Simon Baudry, from Tamines (Belgium), both to the compressing and to the drying apparatus. In Martin's process, the lumps of fuel would be delivered from the rollers on a short endless belt, from which they fell into very open-worked baskets. When filled, these baskets were carried away by boys and placed on shelves, under a shed, where the coal dried by simple exposure to the air. The roof of that shed was composed of sections of water-proof canvass, which were rolled up during fair weather. This slow and very imperfect method of drying economized fuel, but required a large number of boys.

Baudry invented a drying oven, with shelves all around; the fuel coming from the press would fall on perforated sheet iron trays instead of falling into baskets, and these trays were placed on the shelves in the oven. It required two hours to dry the fuel. The oven was then opened at both ends, and as fast as the trays containing dry fuel were removed from it, they were replaced by others containing freshly moulded fuel, which had been temporarily piled up near the oven. During this operation, the doors being open, the interior of the oven cooled down gradually, the work of removing its contents and of filling it anew had to be done very rapidly, and required also a large number of boys. Labor being relatively cheap in

Belgium and coal selling high, no improvements have been made to suppress unnecessary handling. Notwithstanding the defects of Baudry's process, it is still applied in Belgium, the product containing 18 per cent. of clay and not being impervious to moisture. The large percentage of clay and the fuel not being able to stand exposure to the weather are the greatest obstacles to the development of the manufacture of artificial fuel by the use of clay as a cement. Mr. Henry Gerondeau from Liege (Belgium), in an article on the agglomeration of coal dust, published in 1861, says that "if the proportion of clay could be reduced to a small percentage, and the product be made impervious to moisture, clay, which is the best and the cheapest, would undoubtedly supersede all other cements."

As I have said before, asphalt, rosin and petroleum have also been used as cements, but these materials have been found wanting in cohesive property, and also too expensive. Coal tar and its derivative, fluid pitch and dry pitch, have been the most extensively used.

The idea of mixing coal dust with coal tar originated with Peter Davey, an Englishman, who, in 1821, took out an English patent for what he describes as "consisting in an improved preparation for coal for fuel, which I call gaseous coke, and which is made of very small coals, mixed with coal tar (either in a pure state, which is best, or combined with naphtha and these other ingredients with which it is generally found impregnated), and then cemented together by the application of heat, in the form of large lumps or cakes, for the purpose of fuel." The mixture is pressed into moulds, which are placed for four hours in an air furnace heated to 350° Fah.

This same Peter Davey had obtained, 21 years before, in 1800, an English patent for an improved fuel, which he describes thus: "Small coals are mixed with charcoal or wood, breeze, turf, tan, saw-dust, cork-cuttings, peat, or other inflammable ingredient or ingredients. These materials are then well mixed and put into kilns, ovens or other furnaces, either dry or moistened, and, by means of dampers, slides, vent or air holes, or other contrivances, the heat is so regulated as to be equal to cementing the materials without destroying them."

This was rather a singular mixture of ingredients, but Peter Davey persevered in his researches, and during the 21 years which elapsed between the dates of his two patents, God only knows what dreadful mixtures that man must have tried.

During those 21 years no patents were applied for in England, and

two only were issued in France—one to a Mr. Quest, June 18th, 1810, for a mixture of coal dust and clay, and another to a Mr. Burette, June 12th, 1811, for compressing bituminous coal dust without cement. Peter Davey, then, may be considered the father of the artificial fuel industry.

From 1821 to this day a considerable number of patents have been issued, both in this country and abroad, either for so-called new processes or for the machines to apply them.

Coal tar was first used in France by Ferrand and Marsais. Their first experiments commenced in 1832, but, after a great many unsuccessful attempts, Mr. Ferrand having died, Mr. Marsais abandoned coal tar and tried fluid pitch. This was a successful stroke. He erected, in 1842, a factory at Berard, near St. Etienne, which was in operation during three years. He then removed his establishment to Gisors, where the coal company of St. Etienne is still manufacturing artificial fuel by Mr. Marsais' process, and that in the same factory erected by him 28 years ago.

Among the inventors who have really improved the means of manufacturing artificial fuel, by using either coal tar, fluid pitch or dry pitch, the names of Grant, Rathwell, Cooke, Wylam, Warlich, Dobrée, Moreau and De Haynin are prominent.

Fluid and dry pitch formed a good cement for bituminous and semi-bituminous coal dust, but it did not succeed as well with anthracite and semi-anthracite waste, which is mined in South Wales and in some parts of France and Belgium. Before the cement is consumed the bituminous artificial fuel is coked, and consequently it does not crumble in the fire. It is not the same with anthracite or lean coal dust. When cemented with coal tar or pitch, or any other resinous material, the cement consumes in the fire more rapidly than the coal, and the particles of coal, having lost their adhesive coating, crumble in the fire and fall through the grates without being consumed.

Resinous materials expand when burning, while clay, on the contrary, contracts progressively when submitted to elevated temperatures. Clay, used alone, would not have given a fuel impervious to moisture. It was supposed that, by mixing clay and pitch with the coal dust, the fuel manufactured would not only be waterproof, but would remain in the fire, without crumbling, until consumed, the shrinkage of the clay compensating for the swelling of the pitch.

Among the experimenters in that direction we have men who have really improved the manufacture of artificial fuel. The most eminent

of those inventors are Chabannes, Sunderlandt, Stafford, Oram, Geary, Goodwin, Mohum, Sterling, Albert, Newton, Holcombe, and one of the great Smith family.

All these attempts were unsuccessful. The presence of pitch in the fuel made it unfit for domestic use, and the clay impaired its combustible character for manufacturing purposes.

Patents were also granted to several inventors for a mixture of bituminous and of anthracite coal dust and coking the mixture. The first one of these patents was granted, in 1823, to John Christie and Thomas Harper, in England.

The result was the same as with Bessemer, Baroulier and others. The machinery was too expensive and the product was not marketable. The coke had no density, it was very porous, owing to the fact that the particles of anthracite would not unite with the bituminous and remained in a loose state in the cells of the coke. It burned well enough, but it was rapidly consumed, and could not bear handling.

In 1838, April 26th, a patent was granted in England to Thomas Joyce, of Camberwell, for "certain improved modes of applying prepared fuel for the purpose of generating steam and evaporating fluids, the fuel to be used in chambers or furnaces, to be wood, coke, coal, charcoal or other fuel, prepared, chopped or broken into small pieces, so as to insure its falling down the fuel chamber, as the lower part of the fuel is consumed. It may be saturated with an alkali solution."

The combustion chamber consists "of a vertical cylinder, with a grate and apertures to support combustion at the bottom; it is filled with fuel which only burns at the lower part, the upper part falling down as that below burns away; the flame and smoke pass out through side passages surrounded by the water in the boiler."

This same inventor, on the 12th of November, 1838, obtained also a patent in this country.

The United States patent seems to have been confined to the fuel as used in a stove for heating rooms, etc. The invention made much noise at the time, and was considered a real improvement by many persons eminent in chemical science, but the plan was long since abandoned, and considered as an utter failure. The proposed fuel in this patent consisted of charcoal heated with potash, and the stove was to be without a pipe, the products of combustion all escaping into the room. The carbonic acid was to combine with the potash, and thus to prevent all injurious effects from it.

The English patent of Thomas Joyce contained, evidently, the germ of the self-feeding anthracite stoves in general use to-day.

In 1845, Richard Archibald Brooman obtained an English patent for "mixing coal waste with india rubber and gutta percha combined, or each of these alone." This was quite an elastic cement.

The most singular patent ever issued, was granted in 1840 to Thomas Kerr, of England, for a new composition for artificial fuel and other purposes. This composition is formed, first of the "rakings of roads, or streets, or other public ways, or the sweepings of houses, offices and other buildings, or of the ashes of coal or other fires, or of small coal, culm, breeze, or of river or sea sand or of free stone, or other stones pounded into dust, or of any other mineral or vegetable substance in a state of dust or powder.

Secondly, of chalk or any other similar calcareous substance of a drying and retaining nature, ground into a fine powder.

"Thirdly of tar, or pitch, or oil, or rosin, or some other substance of the like bituminous, fatty, or inflammable nature, such as the common archangel tar, in the same state as imported, coal tar as it comes from the gas works, the pitch that is manufactured from coal after the naphtha has been extracted, whale oil, linseed oil and other oils, and,

"Fourthly, simple clay or common salt. These ingredients described under these four heads are combined in a variety of proportions and used for fuel, and * * * for an infinity of other purposes."

Now, what on earth can those other purposes have been.

Some Americans, or naturalized Americans, seem to have been as erratic as this Englishman was. I find three patents granted in 1865 for the following compounds :

To Henry Redlich, June 27th.

Coal dust,	.	.	.	4 parts.
Cow dung,	.	.	.	3 "
Blood,	.	.	.	1 "

To Chas. Korff, July 4th, one week after Henry Redlich.

One ton,	.	.	.	Coal dust.
One gallon,	.	.	.	Blood.
One gallon,	.	.	.	Water.

Such a patent granted on the anniversary of American independence. This Korff had evidently contracted his disease from Redlich.

To Samuel D. Hovey, October 24th.

100 parts,	.	.	Coal dust.
1 “	.	.	Glue.

Some inventors, thinking that coal does not contain sulphur enough and probably supposing that it improves the fuel, especially for metallurgical purposes, add to their mixture, as described in their specifications, large quantities of sulphur, some of them as much as three per cent.

A large number of patents have been granted in this country for artificial fuel. Most of them are modified copies of foreign patents, and a good number denote in their description a complete ignorance of the calorific properties of fuel and of the laws of combustion. The only one which, in my opinion, possesses real merit has been lately granted to Doctor Joshua R. Hayes, of Winchester, Pa. This patent was issued on March the 4th, 1873.

Mr Hayes uses coal dust, clay and asphaltum, but although the manner in which he combines these materials is new and ingenious, the product will be liable to the same objections made against the fuel manufactured in Europe from coal dust, clay and pitch, by Stafford, Oram, Goodwin, Geary and others.

The manufacture of artificial fuel, although being far from having attained the importance which it must attain in the near future, has been developed more rapidly in France and in Belgium than in England. English coal is harder than French and Belgian coal, and until within the last three years, the price of coal in England was so low that there was no inducement for capitalists to invest their money for the development of an industry which presented but poor prospects of good dividends. But increase after increase in the price of coal, during the last three years, has entirely changed the state of affairs. Large companies have been organized last year, with immense capital, for the manufacture of “patent fuel” by different processes. The last one patented in England, and which has also been patented in this country is the invention of Martin Rae of Uphall, North Britain.

It consists in mixing with coal dust 15 per cent. of what he calls a bituminous *mastic*. This mastic is prepared in the following manner: Crude shale tar obtained in the distillation and refining of mineral oil from bituminous shale, is freed from sulphuric acid by means of steaming and washing in lime water. It is then run into a still, where the water and a portion of the oils is distilled off, which process renders the shale tar more dense and tenacious, being in a state between tar and pitch, (which is exactly the state of what is called fluid pitch).

A pipe from the bottom of the still conveys the mastic to a pan where the heat is kept up to about 200° Fahrenheit. From this pan the mixing machine, containing the coal dust mixed with about five per cent. of powdered clay, is supplied with the requisite proportion of mastic.

From the mixer the plastic mass is conveyed to a press, to be moulded, and from there to the drying oven. In this process we have again a mixture of clay, coal dust and some other bituminous material, fluid shale pitch.

A company was organized in May, 1873, with a capital of \$1,000,000 under the name of the "Diamond Fuel Company," to apply David Barker's process.

In this process, a peculiar mucilage is mixed with the coal dust in the proportion of two ounces of mucilage to one pound of coal dust. The mucilage is manufactured in the following manner: One part of farina from which the gluten has been removed and which consists entirely or almost entirely of fecula or starch, is mixed with twenty parts of water, and to this is added a solution of sulphate of alumina or of chloride of alumina in hydrochloric acid, in the proportion of one ounce per gallon. The mixture thus formed is conveyed into a tank heated by steam, in which it is boiled and then run off, through a tap, into a boiler in which are placed pitch and carbolic acid, in the proportion of eight parts of the former to two of the latter. The whole contents of the boiler are subjected to the operation of boiling under moderate pressure, by which treatment the several substances contained in the boiler are caused to unite. Steam is then turned on into the boiler, and the contents thereof forced through pipes into a tank, whence the liquid is conveyed to the mixer by means of elevators, cased with sheet iron and wood, between which steam is introduced to keep the liquid from solidifying. In the mixer the coal dust is conveyed by a separate set of elevators, and is thoroughly amalgamated with the above described compound. The mixture is then compressed into lumps and dried in an oven.

It will be observed that in these two processes, as well as in the old one of cementing coal dust with pitch, or rosin, or asphalt, a large amount of natural coal is consumed, not only to dry or carbonize the product, but also to heat the cement and the coal dust itself. If the dust was not heated, the cement would not adhere to the particles of coal. There is also the unnecessary handling in carrying the fuel to the drying oven and removing it when dry.

Both Martin Rae and David Barker are inventors, not only of the process, but of the machinery for its application.

The mixing machines in Europe are almost all constructed on the same plan; they consist of vertical or horizontal cylinders, differing only in diameter, in height, or in length. In the centre revolves invariably an upright or horizontal shaft, to which are fastened, by set screws, a series of knives, blades, arms or paddles, set at a certain angle to force the materials downward or forward. To prevent the cooling of the materials, all the mixers are either surrounded with steam jackets, or furnished with openings, to which are adapted steam pipes to convey steam into the mixer. Some of those mixers have steam passing through the shaft and even through the arms or paddles. No improvements, worth noticing, have been made in the mixing apparatus for the last 40 years, while the compressing machines have been improved from year to year. This singular fact was noticed by Mr. L. Gruner, who, in a very elaborate article on artificial fuel, published in 1865, said that "it was to be regretted that the efforts of inventors had been almost exclusively directed towards improving the compressing machines." He had no doubt that if the mixing of the materials was more complete, if they should remain longer in the mixer, the proportion of cement, no matter what that cement should be, could be reduced considerably, which would, as a natural consequence, reduce the cost of fuel. To attain this very desirable object, he suggested an increase in the diameter of the mixer. The suggestion was a good one, still no improvements were made. I have seen at Bouffloulx, Belgium, a vertical mixer, about 20 feet high; it was calculated that with such a mixer, the materials would remain in the apparatus about half an hour, instead of ten minutes and sometimes less, as they did before. The pressure of the column of coal dust was so great that, when the power was applied, all the arms broke off one after another, except the six upper ones. This mixer was then replaced by an horizontal cylinder, forty feet in length. It worked better than the former, but the mixture not being plastic enough, two horizontal mixers were placed above one another. The materials falling into the hopper of the first one, would travel the entire length of said mixer and be discharged into the hopper of the lower one, at the end of which the materials would come out in a perfect plastic state and ready for compression. At Montigny-sur-Sambre, Belgium, Mr. Dehaynin used an horizontal mixer about 65 feet (20 metres) in length, heated all around; it may be imagined what trouble it must have been to keep such an apparatus in good working order.

Although the compressing machines used in Europe are numerous, they are all modifications of four distinct mechanical modes of applying pressure. First, by means of rollers; second, by pistons in closed moulds; third, by pistons in open moulds, and fourth, by pistons pressing cylindrical lumps with a hole through the centre.

Under the first-class, we have the following machines.

An endless chain, carrying moulds, working horizontally on a long table, passes under a hopper, from which sufficient material in a loose state is supplied to the moulds, to obtain lumps of a given density when compressed. These moulds pass under a roller, which revolves in an opposite direction and forces the loose materials into the moulds. The lumps are then discharged from the moulds by a piston. This machine was also invented by Bessemer and has been in operation in England and in France to make bricks.

Another machine has two rollers, revolving in opposite directions, one of which has on its face square cavities with movable bottoms, the face of the other roller being smooth. The plastic mass, fed between the rollers from a hopper above, is forced by the smooth roller into the cavities of the other one. At the lowest point of the course of this last roller, the movable bottoms are pushed forward by an eccentric, and the lumps being relieved fall on an endless belt, from which they are taken by hand and piled up in cars to be dried. This is more a moulding than a compressing machine. It was the invention of a German named Milch, and has been in use at Halle, Germany, to press lignite.

A third machine, invented by Mr. David, of Havre, has also two rollers, one of which has, like the preceding one, square cavities with movable bottoms, while the other one has projections which exactly fit those cavities. The plastic mass is forced into them by those projections, and at the same time, by an ingenious device, the bottom of each mould is alternately pushed forward a certain distance, so that the materials are pressed on both sides. An eccentric, as in Milch's machine, pushes the bottoms of the moulds far enough to relieve the lumps which fall also on an endless belt. The removal of these lumps and their drying is done by boys, who receive them in baskets as they fall from the endless belt. This machine is in operation at Montchanin, Brest, Caen, and Havre.

A fourth machine, the invention of Mr. Jarlot, of Lorient, France, has two very peculiar rollers. Their thickness is about three inches. To one side of each is bolted a cast iron cylindrical ring eight inches in

thickness and eight inches face. Through that thickness are bored, at certain distances, cylindrical holes, of larger diameter on the face and gradually reduced about one-tenth at the other end. The rollers are so placed that, when they revolve in opposite directions, the solid space between the openings of one roller exactly meet the openings of the other. A certain quantity of plastic mass is thus forced alternately in the openings of each ring, and the fresh materials forced in push forward towards the end of the opening, the coal which it contained already. Pressure in this machine is produced by friction of the materials along the sides of the openings. At each revolution of the rollers some more material is forced in, and the pressed fuel gradually emerges inside the ring, in a continuous cylindrical shape. When it is projecting a certain length, a stationary knife, which can be adjusted, cuts it off, and the lump falls along an incline planed into wire baskets, to be carried to the drying oven. This machine is in operation at Languin and at Bordeaux, France.

There has also been in use, during a few months, with very poor results, a machine invented by Mr. Verpilleux, of Rive de Gier, France. He used two smooth rollers, one of which was adjustable, so as to separate it from the other at any desired point. The plastic mass passed between these rollers as a thick band and was cut into sections by a revolving knife, placed underneath. This was simply laminating but not compressing.

I have described Martin's and Baudry's machines at length. As you will remember, they use two rollers having on their peripheries one-half of an ovoid or egg-shaped mould. It is on the principle of these machines that my press is constructed.

The following are among the inventors whose machines, compressing by a piston in a closed mould, belong to the second class, viz: Marsais, Poplin Ducarre, Moreau & David, Middleton, Mazeline & Couillard, and Revollier.

Marsais compresses the coal, by hydraulic pressure, into large and very heavy square moulds. These moulds have lids and also movable bottoms. When filled with the materials the lids are bolted to the moulds, and these are carried under an hydraulic press. The movable bottom is pushed upward and compresses the contents of the mould against the lid. A safety valve opens when the pressure exceeds certain limits. The lid is then removed, and the mould is carried under another press, which pushes the movable bottom upward with the lump on it. This lump is placed on a car and carried to the

drying oven. It requires ten minutes to mould one lump, which weighs about 465 kilograms or very near 1000 pounds. After being dried it is broken to pieces with hammers. In breaking it a large amount of the fuel is again reduced to dust.

Poplin Ducarre's press, like that of Moreau & David and others, is composed of a series of pistons, placed vertically or horizontally, pressing the coal into a series of moulds placed in the same way. When the pressure is applied by vertical pistons, there are two series of these working alternately; one to press the coal and the other to push the lumps out of the moulds. The frame containing the moulds is movable, and is placed on a stationary perforated table. When the coal is pressed and the compressing pistons have left the moulds, the frame which holds these moves sideways, so as to bring the bottom opening of the moulds exactly over the perforations of the stationary table. The lumps are then forced out of the moulds through those perforations by the other pistons. The moulding frame returns to its place, and the same operation recommences.

This machine is only used for the manufacture of what is known as "Charbon de Paris." The materials are charcoal dust, saw dust and coal tar. The lumps are cylindrical.

When the pistons are placed horizontally, the moulds remain stationary and the materials are pressed against strong movable gates. In this case we have a double set of moulds and pistons, and the same pistons both compress and discharge the lumps. The mixture, which fills the moulds from hoppers or from chutes communicating with the mixing machine, is first pressed against the gate of one side, which moves up and down in front of the moulds, and by a further pressure the lumps are discharged, while the gate comes down. During this operation the gate on the opposite side comes up and the moulds are filling. The same operation is then repeated by the other set of pistons. Both sets are worked by a yoke and cams. This model, although having only one mould on each side, can give you an idea of that kind of machine.

A serious defect of these presses is that the pressure is not gradual, but is given by a sudden blow. The feeding being very irregular, the lumps have not a regular density. Their production does not exceed 25 tons per day, the lumps weighing four pounds each.

Machines constructed on the same principle and which I have found, by personal experiments at Nesquehoning, to possess the same defects, have been patented in this country by John B. Collen and by T. M. Mitchell, both of Philadelphia.

The presses of Middleton, Revollier, and Mazeline & Couillard, have a solid circular turning table, containing a series of square moulds. While the table is revolving, the moulds pass in succession under a mixer or pug mill from which they are filled. In the centre of this mixer or pug mill is an upright shaft, to which are fastened, by set screws, and at any desired angle, a series of knives, which mix the materials and force them downward.

In Middleton's press, this turning table is placed so as to rest upon a stationary one, having the same diameter. The stationary table serves as bottom to the moulds of the turning one and has only one large square opening, through which each lump is discharged. The motion imparted to the moulding table is intermittent. The moulds are successively brought under a pug mill to be filled, then under a piston which compresses the materials against the stationary table, and finally under a second piston, which forces the lump out of the mould, through the opening described before, so that, while one mould is being filled, a lump of artificial fuel is pressed and another one is discharged. This press, which was at first adopted in all the Belgian factories, has a great defect. The jerking motion of the turning table has to be regulated with the greatest precision, so that the compressing piston and the discharging one exactly meet the moulds. The slightest deviation would break the piston rods. Middleton's press has been replaced everywhere in France and in Belgium by Revollier's press for a large production, and by Mazeline & Couillard's press for a small one.

In Mazeline & Couillard's press the moulding table revolves continually. In each mould is a movable bottom, having a small roller under it. These bottoms travel on an inclined helicoidal plane. Whenever a filled mould passes under a strong cast iron block, the bottom gradually comes up the incline plane and compresses the materials against that block, and while the rotary motion keeps on, the lump is gradually brought to the surface of the moulding wheel. At this point a scraper, worked by an eccentric, pushes the lump on an endless belt and springs back to push off again the next lump, and so on. The bottom of each mould gradually comes down and leaves room for the plastic mass to fall into it from the mixer. The lumps weigh about 20 pounds; as the moulding table contains 10 moulds and makes $2\frac{1}{2}$ revolutions every minute, the production is from 13 to 14 tons per hour.

These machines are in operation at Blanzey, Anzin, Valenciennes

and Havre, in France, also in England, Germany, Belgium, and even in two factories erected last year in Spain.

Mr. Revollier compresses by hydraulic pressure. The moulding table of this machine is about 10 feet in diameter, and is divided in four sections, each one of which contains a certain number of moulds, according to the size desired; in each mould is an independent movable bottom. During each revolution the table stops four times. The moulds of one section are all filled at the same time; the table then makes one-fourth of a revolution and brings that section under a strongcast iron block and over the pressing plate. This plate forces all the movable bottoms upward, compressing the coal contained in the moulds against the block. Another fourth of a revolution brings that section over a second plate, which works upward in the same manner as the pressing plate, and forces all the lumps out of the moulds at one stroke; where the moulding table completes a revolution, the lumps are placed in front of a scraper, worked by an eccentric. This scraper comes forward and pushes all the lumps at once on an endless belt, from which they are taken by boys. Although this seems to be a very slow method of compressing coal dust, the production exceeds that of Mazeline and Couillard's press, because each stroke of the piston makes 20, 30, and even 40 lumps, according to their size. The press is so constructed that the moulds can be changed at will, when larger or smaller lumps are required for the market. The production of this press varies from 20 to 25 tons per hour.

Bessemer's first machine, by which the coal dust, heated to a plastic mass, was forced through a long tube, belongs to the third class of presses. As I have said before, the tube was reduced in length and increased in thickness, on account of its bursting very often.

Mr. Evrard improved Bessemer's process in this manner. Sixteen cylindrical moulds are placed horizontally on a turning table, as the radius of a circle; each mould contains a piston and is open on top sufficiently to receive the plastic mass from the mixer, while it passes under it. The pistons are worked by means of a strong eccentric and of 16 short links. The cylindrical end of the moulds is formed by two semi-cylindrical sections screwed together, so as to allow some space between them, if necessary. At each stroke of a piston, a small lump is pushed out of the mould. The pressure is applied gradually and, as a consequence, the lumps are solid and have no cracks.

These machines are in operation at La Chazotte, La Grand Combe, France, and have also been tried by Mr. Dehaynin at Montigny-sur-sambre, Belgium, but their production being very limited, Revollier's press was preferred.

Mr. Moreau, of Paris, manufactures cylindrical lumps by using a horizontal cylinder, slightly conical at the end. In this cylinder revolves a screw which pushes the materials, falling into the cylinder from a hopper placed above it, towards the conical end, and forces the plastic mixture out through a small cylindrical opening. As fast as the pressed fuel emerges from the cylinder, it is cut into sections of any required length by a revolving knife. This is an imitation of a machine invented by Mr. Devineck, of Paris, for the manufacture of chocolate sticks.

The fourth class includes different apparatus which are simply modifications of machines used in the manufacture of hollow bricks and of drain pipes. Mr. Dehaynin, tried in his factory of Montigny-sur-sambre, a machine of that kind, patented by a Mr. Bourrier. The results were not favorable. Mr. Dehaynin has been the most persevering man in the artificial fuel industry. He has encouraged inventors in that line, tried their machines and has furnished a great many with the means for experimenting. He is to-day the proprietor of four establishments, in which 1,500 tons of artificial fuel are manufactured daily for the railroads and for the French navy. He has acquired immense wealth and he certainly deserves it.

Most of the machines which I have described have also been tried to convert peat into a dense fuel. Some of them have answered the purpose very well—Milch's machine, for instance. Large peat factories are in operation at Stalbach, Halle, Haspelmoor and Neudstadt, in Germany, and at Montangin in France.

I have derived very valuable information on the subject of artificial fuel from Messrs. Gruner and Gerondeau's works, from Armen-gaud's publications, from several European scientific publications, and especially from the Philadelphia Journal of Industry published in 1870 by Henry Howson, the well-known patent attorney.

Having given you a summary description of the different processes and of the machinery used for their application, I will now proceed to describe what appears to be their deficiencies.

It is evident that no artificial fuel containing a resinous substance will ever be used for domestic purposes, on account of the smoke and of the bad odor. Another objection is that such a fuel is liable to

spontaneous combustion. No objection of the kind can be raised against artificial fuel cemented with clay and milk of lime.

By mixing the coal dust and the cement in a vessel which contains only one single shaft with blades the materials are turned around, always in the same direction; it takes a long time before they are brought to a plastic state. Increasing the length or the number of horizontal mixers requires too much valuable space and is very expensive. A better result would certainly be obtained if the diameter of a vertical mixer was increased and if several upright shafts commanding each other and consequently revolving in opposite directions, were used instead of a single one. The knives of these shafts crossing each other in all directions, would undoubtedly perform a quicker and better work than the blades of one single shaft. Practical experiments have demonstrated this fact.

T. M. Mitchell, of Philadelphia, the patentee of different machines erected at Nesquehoning, Carbon County, Pa., used a vertical mixer with four shafts, which worked very well. It had, however, some defects. There was no possibility of ascertaining if the mixture had acquired a sufficient degree of plasticity, and when the mixer had to be cleaned, or some obstacle had to be removed from it, or some arm broke and had to be replaced, the whole machine had to be taken to pieces, which occasioned much trouble and a considerable loss of time. Still it was a decided improvement on all the European mixers. It is with that apparatus that I succeeded in reducing the proportion of clay to five per cent.

In my process, I use the slack without heating it or drying it previously. The moisture which it contains varies with the state of the atmosphere. Therefore I am compelled to regulate the supply of lime water accordingly. The difficulty of ascertaining the state of the materials, inside the mixer, suggested the idea of placing sliding doors around it. These doors facilitate the cleaning of the mixer and the removal of stones or pieces of iron which are found quite often in the coal dust. By means of a movable spider, which allows the removal of each shaft without interfering with the others and without removing the stationary frame in which they stand, a broken arm or a worn out one can be replaced by new ones in half an hour.

Although the compressing part of some only of the European presses is defective, the feeding part of almost all of them is very deficient. The materials to be pressed containing at certain times more moisture than at other times, the feeding of these materials to

the press ought to be reduced or increased accordingly, and, to effect that purpose, simple and efficient means are necessary.

The pressure should be applied gradually in order to expel, as much as possible, the moisture contained in the mixture and avoid cracks, which are the unavoidable result of a sudden pressure. An excess of compression spoils the fuel, prevents its free burning, and makes the ashes adhere to the surface of the lump, instead of falling through the grate into the ash pan. The fuel must be sufficiently compressed to bear transportation and reasonable handling and be still porous enough to insure free combustion.

The shape of the fuel is also of great importance. Square lumps have too many sharp edges which break off easily when the coal is handled, and the flat surfaces meeting very often in the fire prevent the free access of the air. Cylindrical-shaped lumps are better, still they have sharp edges left. Round or egg-shaped lumps are evidently to be preferred. It is not without some good reasons that this shape has met with favor for nearly three centuries in Europe.

To compress the plastic composition into round or egg-shaped lumps it requires less power than is required to compress square ones of the same weight, as there are no corners to fill and, as a result, less friction. With round or egg-shaped lumps, no matter what amount of coal is piled on the fire, there is always sufficient space between the lumps to secure a good draft and to allow a free access for a good supply of oxygen.

For these reasons I have adopted the egg-shaped form, slightly flattened, and have modified Baudry's and Martin's presses, in order to obtain more and better products. Instead of using moulding rollers producing only *one* lump at a time, I increase the length of the rollers and mould fourteen lumps at a time. The feeding is regulated by a pug mill, with a central shaft to which a series of knives is fastened at any required angle, and below these knives, on the same shaft, is a two-bladed propeller. The bottom of this mill is formed by two sliding plates, which can be brought apart and together by hand-wheels. I am thus enabled to increase or reduce the open space between them, and to force more or less plastic material between the rollers, according to the degree of moisture which it possesses. The number of revolutions of the knives can also be increased or reduced by changing one gear wheel, which can be done in a few minutes. A machine is thus obtained, possessing all the good qualities of Baudry's press and having none of its defects. The lump

fall on an endless wire cloth belt and are carried by it directly into the drying oven. This press will produce over ten tons per hour.

The drying of the fuel, in Europe, takes place in ovens. As I have said before, it falls into baskets, or on trays, or is piled up into iron cars having perforated sides and bottoms. Although it requires much unnecessary handling, it must be admitted that with lumps of a considerable size, which remain a long time in the oven before drying, it is a necessity to adopt that system. When large sized lumps are piled up into a car, sufficient space can be left between the lumps to allow a free circulation of the heated atmosphere, but with lumps of a small size this system will not answer, and that for obvious reasons. If the cars are filled, the lumps at the bottom are crushed by the weight of the coal piled on top. The heated air cannot circulate between the lumps. The coal at the bottom, along the sides, and on top of the car will dry, while the centre of the mass retains the moisture. Sometimes, as it happened to me twice at Nesquehoning, the coal at the bottom of the car will catch fire, while the fuel in the centre is still moist.

To avoid the piling up of the coal in cars, and to give to each lump the full benefit of the heated atmosphere of the oven, I place five wire-cloth endless belts on the top of one another, leaving sufficient space between them. The belts command each other and they travel, in opposite directions, the entire length of the oven. The top belt comes directly from the press, with the pressed fuel on it, and it travels the entire length of the tunnel, at the slow speed of 12 feet in a minute; five times in succession is the coal carried through the tunnel, falling along chutes from one belt to the other, and it comes out on the fifth and lowest belt perfectly dry. The length of the oven is 100 feet.

The wire-cloth belts are strengthened by wire ropes, placed under them and in the centre. The wire-cloth is fastened to the wire rope by iron balls, cast in two pieces, each half having a recess for the wire rope to fit in; one of these half spheres receives the wire rope first, then the wire cloth is placed over it, and finally the other half is placed on the wire-cloth and the whole is solidly fastened together by a bolt which passes perpendicularly through the balls. These balls act like the cogs of a cog wheel, and run in a gutter placed under the centre of each belt, thus supporting the weight of the belt and of the coal on it. Each roller has four recesses in which the balls successively fall, thus preventing the slipping of the belt.

In this system all handling is suppressed. No cars, tracks, hooks, turning tables, etc., are necessary. The doors of the oven are always closed and consequently the heat in the oven can be kept up to any degree; the iron in the oven is not liable to contraction and expansion and less coal is consumed to dry the manufactured fuel.

To render the fuel impervious to moisture, instead of mixing a resinous substance with the materials, the lumps are simply dipped into a liquid composed of rosin number three dissolved in crude benzine. By exposure to a current of air the benzine evaporates, and leaves each lump coated with a thin film of rosin, which closes all the interstices and renders the fuel waterproof. I have kept lumps under water for three months. Here are some which have been kept for two months in this glass vessel at the American Institute Exhibition in New York. The only effect of the water on the coal is to turn the varnish with which it is coated to a greyish color.

This working model of my machinery will explain the entire process. The coal dust is dumped on a platform and pushed into the hopper of a stationary cylinder, in which revolves a shaft having six radiating partitions, dividing the interior of the cylinder into six equal parts. The coal dust falls between the partitions as they revolve and fills the whole space between them. The rotary motion given to the partitions carries the coal to an opening under the cylinder, where it is discharged. A smaller hopper receives the clay, previously dried and ground. This clay is carried through a smaller cylinder, containing also revolving partitions, and is discharged into the same chute as coal dust, with which it mingles. The space between the partitions of each cylinder are calculated so as to allow the discharge of only five per cent. of clay from the one, and ninety-five per cent. of coal dust from the other. The mixture of coal and clay, while falling under a chain elevator, is sprinkled, in due proportion, with milk of lime, from a tank placed at any desired point. This mixture is then raised, in a moist condition, by the buckets of said elevator, above the hopper of a conveyor in which it is discharged. A screw propeller, revolving in this conveyer, forces the materials into the mixer, where they are rapidly worked into a plastic mass by seven upright shafts. To each one of them, four-toothed arms are secured by set screws.

Through an opening in the bottom of the mixer the plastic mass falls along a chute into the pug mill of the press, and is forced by the knives and the two-bladed propeller between the rollers, where it is moulded into oval lumps which are discharged on the endless - the

cloth belt underneath the press. The lumps are carried by this belt into the drying oven, through which they travel five times, from one belt to the other. They come out on the fifth and lowest belt perfectly dried, and are discharged into the buckets of a second elevator, which carries them up and discharges them on the waterproofing belt. This belt is guided on each side by balls, and is continually immersing itself and the coal on it in the waterproofing liquid, contained in an open tank. On the sides of this tank are grooves describing a curve; under these grooves the balls travel. This tank is kept filled with the waterproofing liquid, supplied from a larger and hermetically closed tank. The belt has small partitions to prevent the sudden fall of the lumps into the mixture, and they also answer the purpose of raking them out of it. When the lumps come out of the bath, the liquid in excess pours in drops through the meshes of the wire-cloth into a gutter placed under it, and, through a pipe, is collected into any suitable vessel.

To evaporate the benzine the fuel coming out of the bath is discharged on the top belt of another oven, which I call the evaporating oven. This one is of smaller dimensions than the drying oven, and it contains only three belts, instead of five; they are also placed above one another. A fan forces air through this oven to evaporate the benzine, while the fuel is travelling from one belt to the other. From the third and lower belt the coal falls through a chute into the coal car standing outside. The end of the chute can be raised to allow sufficient time for the removal of the loaded car and the placing under the chute of an empty one. During this operation the fuel collects in the chute, so that there is no time lost.

From the moment that the coal dust and the clay are thrown into the respective hoppers of the distributing apparatus until the manufactured fuel falls, ready for the market, into the coal car standing outside, the whole process of manufacturing is carried on automatically. During the entire process the fuel is constantly in motion. With 14 men only, a production of 150 tons per day can easily be attained; two presses would be more than sufficient for such a production.

This model was built at the shops of Albright & Stroh, at Mauch Chunk, Pa., where I tried last week a small press constructed on the principle of the one I have patented. It worked to perfection and demonstrated conclusively the practicability of my process. These lumps, which are at your disposal, were manufactured at Albright & Stroh's by that machine. They are exactly of the shape and size have adopted for stove coal.

I was perfectly familiar with this artificial fuel matter when I came to this country. I knew the processes tried and applied in Europe, and also the machines which had been used for the application of those processes. I knew their qualities and their defects, and when my attention was called, six years ago, to the immense accumulations of coal dust considered here as worthless, I concluded that I would benefit mankind and myself if I could make of that waste a marketable product.

I went earnestly at work. I met with difficulties of all kinds, pecuniary difficulties, popular prejudices, old-fogies ideas, opposition of coal dealers, opposition of coal miners; I even was called crazy by members of my own family. I often felt low spirited, but I must say that I was cheered up many a time by encouragements from intelligent and scientific minds.

When I came to Philadelphia, three years ago, I was told that this was not the place for me; that Philadelphians, as a mass, were lacking spirit and business liberality; that no new invention, and especially so in a case like mine, where so many had failed, would receive encouragement or support.

As this was merely an assertion I relied upon my own judgement and experience to find out if its truth was demonstrated by facts. The result of my observations was that Philadelphians were unenthusiastic and somewhat disinclined to accept any new matter on faith, but knowing that, as a natural result, it is characteristic of such a people to hold fast to faith, which they have once based on a conviction of merit, utility and profit, I determined to stick to my task and to remain here. I saw that mere novelty, or loud talking, or humbug of any kind, would not be sufficient to force a matter on the public, but that I had to give substantial evidences of the merits of my invention, of its thoroughness, of its vitality, in order to earn the confidence of Philadelphians.

I made an appeal to the highest scientific authority of this country, to the Franklin Institute of this city, to that institution of which I am proud to be a member and which never refuses to acknowledge an invention of merit. A committee was selected and a very favorable report was made on my fuel in December, 1870. This, after four years of struggles, was the first powerful lift which decided my success. The process was invented, but only part of the machinery for its application.

It is evident, that no matter its utility, its practicability and the

profits to be derived from it, an invention must not be presented to the public too hastily, before it has been well digested or before means have been considered to carry out the proposed end. The inventor must be able to tell to the public not merely that a certain good and profitable object is in view, but that an intelligent plan has been devised for attaining that object, and that the execution of that plan is practicable, that it will benefit the people at large, and also, at the same time, secure remuneration on the capital invested.

To do this I required help, and substantial help. The Lehigh Coal and Navigation company of this city, at the suggestion of its honorable president, Mr. E. W. Clarke, furnished me with all the means, mechanical and financial, to experiment upon my process. This enabled me to study the matter practically, to ascertain the difficulties which I was exposed to meet in the future, and to modify my machinery in order to avoid those difficulties. For this help extended I publicly express gratitude to the Lehigh Coal and Navigation Company, with whose President and officers generally my relations have been most pleasant and agreeable.

I owe also a dept of gratitude to the Press of this city. Publication of the report of this Institute, with very flattering and encouraging editorial comments on my process have been published in the Philadelphia papers. These articles, republished all over the country, have given to my process the notoriety which it has acquired.

To-day, I am glad to say, these experiments are satisfactorily finished, and the product, I believe, will shortly become a commercial article.

THE following figures give the quantities of coal raised in Great Britain, with the loss of life which took place for each year, from 1868 to 1872:—

Date.	Tons of Coal Raised.	Deaths.	Tons of Coal Raised per Death.
1868	104,566,959	1011	103,429
1869	108,003,482	1116	96,777
1870	112,875,525	991	113,900
1871	117,439,251	1075	109,246
1872	123,393,853	1060	116,400

The chances of a collier's life may thus be accurately calculated according to the quantity of coal raised, the ratio being closely preserved year after year with dreadful regularity.

ON A NEW ALLOTROPIC MODIFICATION OF PHOSPHORUS.

BY PROF. EDWIN J. HOUSTON.

In connection with Prof. Elihu Thomson, of the Artizans' Night School, the author has undertaken an extensive series of experiments, resulting, it is believed, in the discovery of a new allotropic modification of phosphorus.

It has long been known that when phosphorus is boiled in strong potassium hydrate, and then allowed to cool slowly, it retains its liquid state for some little time, but that if shaken, or touched by a sharp point, instantly solidifies.

We believe that in the cases heretofore observed, the property of retaining the liquid state, may be owing to the admixture with the ordinary phosphorus of an allotropic modification, having the property of retaining its liquid state indefinitely. Hence, if this modification be obtained sufficiently pure, it would probably exhibit properties strikingly distinct from the common variety. We have therefore instituted a series of experiments, with the following results.

Good phosphorus was taken and boiled repeatedly in strong solution of potassium hydrate, water being occasionally added to replace that lost by evaporation. Care was taken by cautious stirring to prevent the phosphorus from being carried to the surface, by bubbles of the disengaged gas. When the operation had continued for five or ten minutes, the liquid phosphorus was carefully washed by replacing the alkaline solution by a stream of running water. In this way, all the hypo-phosphites were removed, as well as the liquid and gaseous hydrides of phosphorous. The purified liquid phosphorus is now in a condition, which we believe to be a new and hitherto unnoticed allotropic modification. It has the following properties.

1st. That of retaining for an apparently indefinite time its liquid condition, even when exposed to temperatures very considerably below the melting point of ordinary phosphorus. A carefully prepared specimen has been kept by the authors for upwards of *four months*, and is still, at the date of this publication, in the liquid condition. The specimen in question is preserved beneath a water surface in a small test tube. Its weight is about one-eighth of an ounce. The test tube is tied by a string and suspended in a position where it is free from jars or sudden shaking. The room in which it is preserved has been for weeks without a fire, the temperature having often reached a point probably near 40° F., and yet the liquefaction has not been dis-

turbed. There is every reason to believe that this specimen in common with others experimented upon, will instantly solidify on being touched.

A small specimen placed in a test tube and covered by a water surface, was exposed to artificial cold, produced by the rapid evaporation of ether. It solidified at about 38° F. Under more favorable conditions, and with larger masses, it is probable that the temperature could be reduced still lower.

2d. Another respect in which this liquid differs from the ordinary variety is in its non-oxidation on exposure to the air.

3d. It does not shine in the dark. This follows from the preceding property. Several specimens showed no appreciable light when exposed to direct contact with air in a dark room. We regard this very unusual property as suggestive of an allotropic state.

Apparently two modifications of solid phosphorus result from the solidification of the liquid variety. One is tough and waxy, like ordinary phosphorus; the other brittle and crystalline in texture. The best liquid specimens in solidifying, always gave the second variety—indifferent ones, the first. We therefore regard that producing the second, as the true liquid modification.

Rough experiments were made in order to ascertain whether the liquid modification underwent any change in volume by solidification. For this purpose a specimen was placed in a test tube filled with water, and a small capillary tube also filled, passed down into the vessel, and attached to it by a well-fitted cork. Any appreciable change in the volume of the phosphorus would cause a rise of the water in the capillary tube. We expected to find a slight change, but none was observable. This result was probably owing to the expansion occasioned by the heat emitted on solidification, exactly balancing the contraction caused by the passage from the liquid to the solid state. No sudden movement of the capillary column was noticed on the instant of solidification.

In order to see whether the liquid state was due to hydrogen in combination with the phosphorus, we placed small pieces of the solid variety in a tube, whose ends were afterwards drawn out into capillaries, and then, passing hydrogen from a small generator through the tube, melting the phosphorus. A liquid resulted, possessing different properties from that formed by boiling in potassium hydrate. It was quite mobile, of an amber color, and on solidifying, produced the waxy material.

A fact not perhaps well known, was noticed during the conduct of the experiment. A colorless gas was evolved from the free end of the tube which was spontaneously inflammable in air. The heat of this flame was, however, so slight as to render it incapable of igniting the hydrogen issuing with it.

To test the effect of the boiling point upon the production of the allotropic modification, specimens were prepared by long boiling in saturated solution of chloride of zinc. We were unsuccessful in obtaining the liquid modification. A high boiling point cannot, therefore, be assigned as the entire cause of the change.

The substance in question may be merely a very pure phosphorus, yet its liquid condition and non-oxidation can scarcely be ascribed to this circumstance. We therefore consider that the existence of a hitherto unknown liquid modification of the element phosphorus is rendered highly probable. The distinct properties it possesses, apart from the ordinary substance, are much more clearly marked than those upon which the elastic modification of sulphur is based.

It may be mentioned incidentally that the brittle crystalline mass, produced on the passage of the liquid modification to the solid state, differs from the waxy variety of ordinary phosphorus. It oxidises so rapidly on exposure to air as to produce a rise of temperature sufficient for its liquefaction. The liquid thus produced possesses only the properties of ordinary melted phosphorus, and catches fire very readily.

Central High School.

Franklin Institute.

Proceedings of a Special Meeting, held November 10, 1873.

Special meeting of the Institute at the call of the President.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The President stated the object of the meeting to be, to permit the members in attendance to listen to the reading of a paper by Mr. Fred'k Ransome, of England, "On some recent Improvements in the manufacture of Artificial Stone;" and to afford them opportunity for discussing the same, and directed the Secretary to read the application, in virtue of which the special meeting had been called. The Secretary thereupon read an application, signed by twelve members of the In-

stitute, requesting the President, by the authority vested in him by Sec. 2 of Article XII, of the By-Laws, to call a special meeting of the Institute for the purpose specified above.

The President stated, the requisite formality having been complied with, he had authorized the meeting for this evening; and thereupon introduced Mr. Ransome to the meeting.

After the reading of the paper and the discussion thereon, which will be found published in full in the JOURNAL of December, 1873, Mr. Washington Jones moved that the thanks of the meeting be tendered to Mr. Ransome for the interesting and instructive paper which had just been read. The motion was unanimously carried, and the President expressed the sentiment of the meeting to Mr. Ransome. In reply, Mr. Ransome expressed his obligations to the members for the courtesy and attention with which he had been received.

The meeting was then, on motion, adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting held November 19, 1873.

The meeting was called to order at the usual hour.

In the absence of the President, Mr. J. E. Mitchell was called upon to preside.

The minutes of the last stated meeting were read, as also the minutes of the special meeting held November 10th, and were approved.

The Actuary submitted the minutes of the Board of Managers, and of the several standing committees; and reported that at the stated meeting of the Board held November 12th, donations to the Library had been reported from the following sources, as below.

Annales des Ponts et Chaussées, for May, 1873; from the Editor, Paris.

The Locomotive Engine, and Philadelphia's share in its early improvement; from Joseph Harrison, Jr. Philadelphia, 1872.

Metallic Cartridges, as manufactured and tested at the Frankford Arsenal, Philadelphia, Pa. Washington, D. C., 1873. From Major T. J. Treadwell, Ordnance Department U. S. A.

Compagnie Generale pour le curage et l'entretien des Fleuves et des Ports. From J. E. Mitchell, Esq., Philadelphia.

Bulletin of the National Association of Wool Manufacturers, July to September, 1873; from the Association.

Report of the Board of Commissioners of the third Cincinnati Industrial Exposition, 1872; from the Commissioners.

Report of the Commissioner of Education, for 1872; from the Commissioner. Washington, 1873.

The Coal and Iron Trade; embracing Statistics of Pennsylvania, &c., in 1847; from S. C. Bruce, Esq.

Report of the Director of the New York Meteorological Observatory; from the Director. Albany, N. Y.

A Treatise on Machine Tools, &c., as made by William Sellers & Co., Philadelphia, Pa.; from the firm.

First Annual Message of William S. Stokley, Mayor of the City of Philadelphia, with accompanying documents. June 26, 1873. From his Honor, the Mayor.

Belting Facts and Figures. By John H. Cooper, Esq. Philadelphia, 1873. From the Author.

The several special committees of the Institute reported progress and were continued.

In connection with the reports of the committee on the mode of determining the horse-power of steam-boilers, presented and ordered to be published in the JOURNAL, at the last meeting, the Secretary stated that some difference of opinion existed in the minds of several members who had been upon the committee, as to the proper mode of designating the reports in question, and asked for instructions upon this point. The Secretary also read a preliminary introduction which he had prepared to precede the reports, in the Journal.

A motion of Mr. Edward Brown, that the introductory, as read by the Secretary, be inserted in the Journal before the reports, was adopted.

(The reports, with the introductory as ordered, will be found in the Journal for December, 1873.)

The chairman next announced a paper by Mr. J. Luther Ringwalt, on a new process of Engraving. The speaker illustrated his paper by distributing, with other prints, one engraved and printed in the presence of the audience. The paper will be found in full in the Journal for January, 1874.

Mr. Wm. B. Le Van next read a paper on a recent test of an Eberhardt boiler; also another on a recent disastrous steam-boiler explosion. The latter will be found in the Journal for January, 1874.

Mr. C. W. Hunt then read a paper on an automatic railway; a gravity road for the use of coal yards, furnaces, miners, etc., requiring neither steam nor horse-power. The paper will be found in the Journal for December, 1873.

The Secretary then presented his report. Under the head of deferred business, the Secretary called the attention of the meeting to the following from the minutes of the October meeting, viz :

“Under the head of New Business, the President announced the receipt of a communication, signed by sixteen members, requesting that the Library and Reading Room of the Institute be opened on Sundays between the hours of 10 A. M. and 3 P. M. The subject elicited considerable expression of opinion, which was participated in by Messrs. Orr, Le Van and Close. A motion to defer action on the subject until the November meeting, finally prevailed.”

The chairman then announced that this subject, which had been deferred, was before the meeting, and added that he held in hand a paper signed by 42 members, requesting the opening of the Reading Room and Library on Sundays.

Mr. Chabot then offered the following :—

Resolved, That the Library of the Institute be opened on Sundays for the use of the members : seconded by Mr. Wm. B. Le Van.

Mr. Hector Orr opposed the resolution in a lengthy address, and closed by moving to amend the resolution by inserting after the word resolved, the following : “That the request of certain members asking for the opening of the Institute on Sundays, be referred to a special committee to be announced at the next stated meeting of the Institute, and be instructed to examine the entire subject, and report thereon to the Institute.” Seconded by Mr. Chas. S. Close.

Mr. David Branson, after stating the amendment to be indefinite as to time, and that if it prevailed it would be practically an indefinite postponement of the subject, moved the following amendment to the amendment, viz : “That this committee shall consist of ten members, to be appointed by the President, to report on the subject at the next stated meeting, and that five of this committee shall be chosen from amongst the signers of the request.” Seconded by Mr. H. B. Bartol.

Remarks upon the subject were offered by Messrs. Orr, Le Van, Chabot, John Sartain, Close, and others ; finally, upon the question being put to the house, the amendment to the amendment was carried : the amendment as amended was carried, and the original resolution as amended was carried.

In virtue of the foregoing, the President has appointed the following gentlemen to serve as the committee, viz : David Branson (ch.) ; J. B. Knight, C. Chabot, John Sartain, S. F. Corlies, Hector Orr, Henry Cartwright, Fred’k Fraley, J. E. Mitchell, and B. H. Moore.

After the action upon the resolution and amendments, as above, the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting held December 17, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and of the several standing committees, and reported that at the stated meeting of the Board, held December 10th, the following donations to the Library were received, viz :

Notes on the form of Cyclones in the Southern Indian Ocean, and on some of the rules given for avoiding their centres. By C. Meldrum, Esq., M. A., F. R. S. From the Meteorological Society.

Public Ledger Almanacs for the years 1870 to 1873. From Geo. W. Childs, Esq., Philadelphia.

Annales de Chimie et de Physique for April to July, 1873. From the Publishers, Paris.

Bulletin de la Société d'Encouragement pour l'Industrie Nationale, for December, 1872, and May, June, and July, 1873. From the Society.

Comptes Rendus, Nos. 13 to 26, Vol. 76, and No. 1 of Vol. 77, with Index for Vol. 75. From the Academy, Paris.

Traité des Derives de la Houille, etc. Par Charles Girard et G. de Laire. From G. Masson, Editor. Paris.

Annales des Ponts et Chaussées for June, 1873. From the Editor. Paris.

Jahrbuch der K. K. Geologischen Reichsanstalt in Wien, for January, February, and March, 1873. From the Direction.

Verhandlungen derselben, Nos. 1 to 6, 1873. From the same.

Über einen neuen Fossilen Saurier aus Lesina. Von Dr. A. Kornhuber. From the same.

An Investigation of the Orbit of Uranus, with tables of its Motion. By Professor Simon Newcomb, U. S. N. From the Smithsonian Institution.

Proceedings of the Scientific Meetings of the Zoological Society of London, for 1872, part 3, June to December. From the Society.

Zeitschrift des Architekten und Ingenieur Vereins zu Hannover. Volume 19, part 1-2, 1873. From the Society. Hannover.

Journal of the Chemical Society of London, for October, 1873. From the Society. London.

Journal of the Statistical Society, for September, 1873. From the Society. London.

Journal of the Society of Arts of London, October 3d—31st, 1873. From the Society. London.

Chief Engineer's Monthly Report to the Manchester Steam Users' Association, for August and September, 1873. From the Association. Manchester.

Annual Report upon the Improvement of Rivers and Harbors in New Jersey, Pennsylvania, etc. From J. D. Kurtz, Esq.

The Actuary likewise reported the resignation of Messrs. Robert Briggs and William F. Durfee as members of the Board of Managers, and the following resolution of the Board. Resolved, that the Secretary be requested to write to Washington for information concerning a bill reported passed at a recent date, permitting steam boilers used on Western rivers with $\frac{1}{2}$ inch thickness of plates and 54" in diameter, to carry 150 lbs. of steam, and that he be requested to report at the next meeting of the Institute.

The Special Committee on Conflagrations reported progress, and was continued.

The Special Committee to which was referred the request of certain members to open the Reading Room and Library on Sundays presented majority and minority reports: Mr. Henry Cartwright, on behalf of the majority, reported that the Committee had held several meetings, and had discussed the subject in all its bearings. They had decided to refer the subject back to the Institute with the recommendation that it be voted upon by ballot, at the same time as the holding of the annual election for officers, and that due notice of such election be given in the public press. Mr. David Branson presented a minority report, containing a *resumé* of the arguments *pro* and *con* which the subject had called forth, and recommended that it be made the subject of a special election by ballot, to be held on Monday, Tuesday and Wednesday, January 19th, 20th and 21st, 1874, from 10 A. M., to 10 P. M., after due notice to members by postal card, and advertisement of the fact in the public press.

The reports were accepted and the Committee discharged, and upon motion of Dr. Henry Leffmann it was resolved, that the proposition of the majority report, that the vote upon this subject be taken on the day of the annual election, be approved, and that for the special election the polls be open from 10 A. M., to 8 P. M.

Mr. Le Van moved that a special set of Tellers be appointed for the special election, and further, that the Secretary be instructed to give proper notice of the subject to be voted upon through the public press; carried.

Mr. Henry Ashford, of Philadelphia, next presented a paper descriptive of a self-releasing apparatus for boats.

Under the head of New Business, the President stated that nominations for officers for the Institute were in order, explaining that, according to the By-Laws, there were to be elected a President, a Vice-President, a Treasurer, and Secretary, to serve for the term of one year; eight Managers to serve for three years, and two to serve one year, and an Auditor to serve for three years.

In accordance with the foregoing, the following nominations were made:

For President.—Coleman Sellers.

“ *Vice-President.*—Robert E. Rogers.

“ *Treasurer.*—Frederick Fraley.

“ *Secretary.*—William H. Wahl.

For Managers to serve three years.—J. E. Mitchell, F. B. Miles, E. J. Houston, William Helm, William B. Le Van, Samuel Sartain, Charles Bullock, Enoch Lewis.

For Managers to serve one year.—George F. Barker and Theodore D. Rand.

Auditor to serve three years.—William Biddle.

The President thereupon appointed the following members to serve as judges of the annual election for officers, viz:

George Gardom,

Geo. R. Barker,

William A. Rolin,

John W. Nystrom,

Hector Orr,

James Cresson,

John Hoskins;

and the following to act as Tellers for special election, viz:—William Taggart, Theodore D. Rand and William H. Wahl.

Mr. Orr then, in appropriate words, called the attention of the meeting to the recent death of Professor Louis Agassiz, and concluded by moving the following: Resolved, That a committee of three members be appointed to frame a minute expressive of the sense of the Institute at the death of Professor Louis Agassiz. The resolution was carried, and the President designated the following named members to form this committee, viz:—Hector Orr, Dr. J. Gibbons Hunt and Bloomfield H. Moore.

The President then drew attention to the fact that, on the 9th day of December, 1823, the first meeting was held, which culminated shortly afterwards in the formation of the Franklin Institute; and that the first body of officers of the Institute were elected on the 6th of February, 1823. The President suggested the propriety of taking some notice of the interesting fact that the 6th of February next would mark the 50th anniversary of the existence of this Society. It was thereupon moved by Mr. Hector Orr, that a committee be appointed, of which the President be the chairman, to devise some method of properly celebrating the 50th anniversary of the organization of the Franklin Institute, and that this committee have the power to act. The motion prevailed. The President appointed Messrs. Coleman Sellers, Frederick Fraley, B. H. Moore, Hector Orr and William P. Tatham as members of the committee in pursuance of the motion. The meeting then adjourned.

WILLIAM H. WAHL, *Secretary.*

HALL OF THE FRANKLIN INSTITUTE, }
Philadelphia, January 19th, 1874. }

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Meehanic Arts, to whom was referred for examination Wm. M. Henderson's Hydraulic Brake, report, that we have examined said brake and found that it answered to the inventor's description and drawings, which we beg leave to submit in his own words.

The principle involved in the operation of this brake is that of hydraulic pressure, and the motive power is derived directly from the steam boiler of the locomotive. The apparatus consists of three devices: first, a two way cock; second, pressure boxes for applying the brakes, and third, a non-freezing attachment.

The two way cock is placed underneath the foot-plate of the engine, its plug operated by a stem carried up and furnished with a hand-wheel, or lever at top, placed convenient to the hand of the engineer. The branch marked 1 is connected by a piece of wrought pipe directly to the water space of the boiler; the opposite branch, marked 2, is connected by wrought iron pipe and flexible hose connections furnished with valvular couplings between the cars, and leads directly to the pressure boxes, placed at every truck; the third branch is connected directly to the water tank of the tender.

The pressure boxes are of the following construction: a cylindrical

vessel of cast iron is provided, about nine inches in diameter and three inches deep, with about a five-inch hole through it. Two flexible

NOTE.—For Plate referred to in Report of Committee on Science and Arts on Henderson's Hydraulic Brake, see "Journal Franklin Institute," Vol. lxvi, 406.

tube connection which makes an advanced connection with the main pipe, and is also furnished with a stop-cock F. Between the point of junction of these two connections there is placed another stop-cock G.

The non-freezing fluid, preferably glycerin and water in equal parts, which is safe to 30° below zero, is placed above the diaphragm; the pressure is applied below, and in order that the vessel shall remain at all times fully charged with the fluid, a reservoir I is provided on the tender containing an excess quantity. The pipe proceeding from the reservoir to the glycerin vessel has a check valve H fitted to it, opening towards the glycerin vessel, so that should a vacuity occur from accidental leakage, the loss will immediately be made good from the reservoir; a disposition of the fluid to return to the reservoir is instantly checked by the valves closing.

In operation is as follows: When the train is running, the play of the two way cock makes a communication between the tender tank and the pressure boxes (the non-freezing attachment being shut off), by closing the cocks E and F and opening G, and when the engineer desires to apply the brakes, he turns the plug of the two way cock so as to let the boiler pressure act upon the column of water in the main pipe the pressure is transmitted to the diaphragms of the pressure boxes, and, pressing them apart, the brakes are at once applied. To take them off, the engineer turns the plug of the two way cock back again. This shuts off the boiler, destroys the hydraulic pressure, the diaphragms collapse, and the surplus water is discharged into the tender tank without loss of substance or heat.

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HALL OF THE FRANKLIN INSTITUTE, }
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The pressure boxes are of the following construction: a cylindrical

vessel of cast iron is provided, about nine inches in diameter and three inches deep, with about a five-inch hole through it. Two flexible diaphragms of vulcanized india-rubber of disk-form are next introduced, back to back, leaving a space of about half an inch between them, when their flanges rest upon the box; these are secured in position by rings bolting through the whole, making an air-tight joint at the periphery. Into the interior of the disk-form diaphragms, are fitted two rams working in opposite directions, and these are attached by rectangular flanges and bolts to the brake beams carrying the brake shoes; guides are provided for supporting the central casting in position relative to the rams.

The non-freezing attachment is a cylindrical vessel made in halves and embracing at the joint, where it is bolted together, the flange of a double corrugated flexible diaphragm. This vessel is connected to the main pipe by a short tubular connection furnished with a stop-cock E. Leading away from the upper end of this vessel is another tube connection which makes an advanced connection with the main pipe, and is also furnished with a stop-cock F. Between the point of junction of these two connections there is placed another stop-cock G.

The non-freezing fluid, preferably glycerin and water in equal parts, which is safe to 30° below zero, is placed above the diaphragm; the pressure is applied below, and in order that the vessel shall remain at all times fully charged with the fluid, a reservoir I is provided on the tender containing an excess quantity. The pipe proceeding from the reservoir to the glycerin vessel has a check valve H fitted to it, opening towards the glycerin vessel, so that should a vacuity occur from accidental leakage, the loss will immediately be made good from the reservoir; a disposition of the fluid to return to the reservoir is instantly checked by the valves closing.

In operation is as follows: When the train is running, the play of the two way cock makes a communication between the tender tank and the pressure boxes (the non-freezing attachment being shut off), by closing the cocks E and F and opening G, and when the engineer desires to apply the brakes, he turns the plug of the two way cock so as to let the boiler pressure act upon the column of water in the main pipe the pressure is transmitted to the diaphragms of the pressure boxes, and, pressing them apart, the brakes are at once applied. To take them off, the engineer turns the plug of the two way cock back again. This shuts off the boiler, destroys the hydraulic pressure, the diaphragms collapse, and the surplus water is discharged into the tender tank without loss of substance or heat.

The non-freezing attachment will only be required during cold weather, and is brought into service by closing the cock G and opening cocks E and F. The operation of the two way cock is the same, but the diaphragm separates the two fluids from commingling and the return of the non-freezing fluid is made to the glycerin vessel.

The saving claimed for this invention is as follows: Doing away with all pumps, cylinders under the cars, with their necessary pistons, packing, stuffing-boxes, recoil-springs, levers and rods for working them, and the lubrication of all; exclusion of dust from vital parts and a continuous waste of steam and heat in working pumps, immunity from wear and tear in working and repairing complicated machinery. Your committee have only examined this invention in shop, and by the aid of drawings and descriptions, and not in actual service on railroad cars in use, but can venture to make the general statement that that brake which is in every way efficient with the smallest number of simplest parts, and if those parts can be applied, repaired, and managed by men of ordinary ability, must be superior to all others. It is of the greatest importance in the construction of railway machinery, that it is simple, durable and not liable to derangement, and its essential features should be ease and certainty of control. In reference to the non-freezing attachment, we find, on consulting the authorities, that glycerin will mix with water in all proportions, and that with 40 per cent. of glycerin, water will not freeze at the zero of Fahrenheit, with 50 per cent. it will not freeze at 23.8° Fahrenheit, and that pure glycerin has never been frozen. When the present high speed of a steam passenger railroad train is considered, the inadequacy of the old brake arrangement, together with the fact that the brakeman is seldom in his right place when called upon, is so glaring as to demand of our railroad companies the use of a more effectual means, which can only be found in those which place the train brakes in the hands of the engineman and brakeman. He who first sees the danger should have it in his power to avert the calamity.

The inventor requests that this report be accepted on the first reading as having been read the second time, for the reason that it has been laid over two months by inadvertance and mistake.

THOMAS SHAW, JOHN H. COOPER,
T. J. LOVEGROVER.

By order of the Committee,

D. SHEPHERD HOLMAN,

Actuary.

JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA.
FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LXVII.]

MARCH, 1874.

No. 3.

EDITORIAL.

ITEMS AND NOVELTIES.

Barker's Improvement in Heating and Ventilation.—

The accompanying report upon this excellent device, to which reference has several times been made by descriptive articles in this journal,* will be read with interest by all who give attention to this important subject :

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, Feb. 16th, 1874.

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the mechanic arts, to whom was referred for examination George R. Barker's Combined Heating and Ventilating Flue Apparatus, report that they have carefully examined Mr. Barker's apparatus for ventilation, both in model and as exemplified in the Franklin Institute building, and conclude that it is the best in efficiency and simplicity that has been brought to our notice. The combination is a very ingenious one, and the experiments submitted prove that the inventor's claim will be well sustained. A description of the apparatus is published in the "Journal of the Franklin Institute" of May, 1873, accompanied by a cut which explains its workings very fully.

Very respectfully,

ADDISON HUTTON, *Chairman,*

JAMES H. CRESSON,

By order of the Committee.

CHAS. S. CLOSE.

D. SHEPHERD HOLMAN, *Actuary.*

* Vide Jour. Frank. Inst., Vol. LXV, p. 292, and Vol. LXVI, p. 368.

Increase of Resisting Power of Metals under Stress.—

In our issue of December last, p. 374, we announced the discovery, made a few weeks earlier,—at the time of the meeting of the National Academy of Science at the Stevens Institute of Technology,—by Professor R. H. Thurston, of a gain in power of resistance observed in metals left under stress during periods varying from one to several days.

The formal announcement of this remarkable and important phenomenon was made to the American Society of Civil Engineers in November, and appeared simultaneously in the Transactions of that Society and in this Journal.

We have lately received, through the kindness of Professor Baird, a memorandum relating to experiments made Jan. 27th and 28th, 1874, by Com. Beardsle, which exhibit a similar action.

The experiments of Professor Thurston were made, with his "Autographic Testing Machine,"* upon a variety of metals; those now presented were made by the ordinary form of Tensile Lever Machine.

This memorandum is as follows:

"TEST OF BLOOM IRON, turned to $\frac{1}{16}$ ths diameter (nearly) = $\frac{1}{2}$ square inch Section. January, 1874.

"Lever ceased to rise at 24,300 pounds. It was then balanced by deducting 1225 pounds, and left, with a balancing strain of **23,075** lbs., from 2 P.M., Jan. 27th, till 7 A.M., Jan. 28th, *when it was found that the lever had raised*, and it took 125 lbs. to rebalance it.

"The strain was then put on gently, and *the lever continued to rise until it reached* **28,250** lbs., *when it ceased to rise and sank*. We balanced the lever at this point by deducting 2,150 lbs. strain.

"Limit of E., 27th,	24,300	Balanced at	23,075
" 28th,	28,250	"	26,100 "

In Professor Thurston's Note to the American Society of Civil Engineers, he states the increase of resisting power noted at a maximum of 25 per cent. in twenty-four hours.

The increase observed in the specimens just referred to is $100 (26,100 - 23,075) \div 23,075 = 13.1$ per cent. in seventeen hours.

The interest and importance attaching to the discovery of these facts to the engineering profession, as well as to science, make it eminently desirable that still further researches should be made on the effect of prolonged stress, compression as well as tensional, and with every variety of material.

* Journal of the Franklin Institute. April, 1873.

We would call particular attention to the fact that the action here noted is not merely a negative one, but, as observed by the original discoverer, is apparently not only an increase in power of resistance but an actual, positive increased molecular effort, as is shown by the rise of the lever during the period of rest in Com. Beardsle's experiment.

A Note on the Resistance of Materials.—BY PROF. ROBERT H. THURSTON.—The following is the text of the communication of Prof. Thurston to the American Society of Civil Engineers, on the subject of certain unexpected results manifested by metals under strain, to which reference was made in the *Journal*, (Vol. lxvi, p. 374). For the copy we are indebted to the Author.

On the 13th ultimo, an apparatus for determining the torsional resistance of materials, which I had designed for use in illustration of my course of instruction, and to which I had fitted an automatic recording attachment, was exhibited to the National Academy of Science, at the late session held at this place, for the purpose of showing the peculiar adaptability of the machine for the determination and analysis of the action of physical and molecular forces in resisting stress, and to illustrate the bearing of experiments already made upon scientific investigations of molecular relation.

At the close of the meeting, a test piece of wrought-iron was left in the machine, exposed to a strain which had passed the limit of elasticity, and with a distortion of 45 degrees, the intention being to determine whether, as has been suspected by some writers and by many engineers, "viscosity" is a property of solids; whether a flow of "solids"* could occur under long continued strain just equilibrating, when first applied, the resisting power of the material, or whether the "polarity" of Prof. Henry is an absolutely unrelaxing force.

The metal was left under strain twenty-four hours, and had not then yielded in the slightest degree. This result and the results of other similar experiments since made confirming it, indicate that metal strained far beyond the limit of elasticity, as above described, does not lose its power of resisting unintermitted static stress.

The important bearing of this fact upon the availability of iron, and of steel, which also behaves similarly, for use in constructions exposed to severe strains, is readily seen.

* Mon. H. Tresca; Sur l'Ecoulement des Corps Solides. Paris, 1869-72.

After noting the result obtained as stated, it was attempted to still further distort the test piece, when the unexpected discovery was made that its resisting power was greater than when left the previous day, an increase of resistance being recorded amounting to about 25 per cent. of the maximum registered the preceding day, and approximating closely to the ultimate resistance of the material. Repeated experiments, continued up to the date of writing, confirm the following previously undemonstrated principle: That iron and steel, if strained beyond the limit of elasticity, and left under the action of the distorting force which has been found just capable of equilibrating their power of resistance, gain resisting power to a degree which has a limit in amount approximating closely, if not coinciding with, the ultimate resistance of the material, and which had a limit as to time, in experiments hitherto made, of three or four days.

Releasing the piece entirely and again submitting it to the same force immediately, does not produce this strengthening action.

There is some evidence that is confirmed by theoretical dynamic principles, that the increase of strength noted is not accompanied by a change of resilience, but that the gain of resisting power is at the expense of a proportional amount of ductility.

The diagrams obtained during this research will be presented at a future time, when the investigation shall have been completed.

The interest and importance attaching to the discovery of the principles above enunciated, to our profession, as well as to science, will, I hope, justify the presentation of this note.

A Third Alpine Tunnel is now proposed. It is to pass under the St. Bernard and will be 20,000 feet long. Under the summit it is proposed to widen the tunnel so as to make a station, and to connect by means of an elevator with the open air. At the mouth of the elevator shaft a hotel will be built, so that Alpine scenery and sunrises may be enjoyed without any personal exertion.

cerin, with a 12-fold increased movement, commences ; that is, if the mercury moved one-quarter of an inch per pound pressure the glycerin moves three inches per pound, by which it is made possible to read the record in ounces when it may be desired.

State and Statistics of Iron Industry.—The recent report of the Secretary of the American Iron and Steel Association, presents an unfavorable resumé of the present condition of the American iron trade. This condition is ascribed directly to the depressing influences of the recent financial crisis. This will appear more evident, when it is remembered that more than *one-half* of the total iron production and importation of the country was consumed by the railroads. The immediate effect of the panic was to check almost completely the construction of new roads, and repairs to old ones, causing a great falling off in demand for iron of all kinds, which depression still continues. The opinion expressed in the report, to the effect that until railroad companies re-enter the market for the supply of all kinds of railway material there can be no general improvement in any branch of the iron business, is, therefore, obviously well founded.

The subjoined tables represent, according to the report, the condition of the iron trade at the beginning of January ; the facts having been obtained by direct correspondence with manufacturers.

Rail Mills.—Of 57 rail mills in the country, which are prepared to make rails of heavy sections, returns have been received during January, from 50. Of the seven not heard from, one is certainly known to be idle, leaving only six from which no information has been received. Of these six, four are mills of small capacity. From the 50 reporting mills, the following information has been received :

Whole number of rail mills,	57
Number of mills making returns	50
“ “ “ running December 31st, 1873,	17
“ “ “ “ full time,	10
“ “ “ “ half time,	7
“ “ “ standing,	33
“ “ “ proposing to resume January,	10
“ “ “ uncertain about resuming,	23
“ “ “ hands wholly unemployed,	11,490
“ “ “ employed half time,	10,150
“ “ “ mills selling rails,	13
“ “ “ not selling rails,	37
Net tons of rails on hand and unsold, December 31st,	36,744

Blast Furnaces.—At the close of 1873, there were 650 blast furnaces in

the country, which were either making pig iron, or were prepared to make it. Returns have been received during January from 385 of these furnaces, or about three fifths of the whole number, showing the number of stacks in blast, the number out of blast, the number of tons of pig iron on hand and unsold on the 1st of January, and the number of hands then out of employment. These returns are tabulated below :

COMPLETE TABLE BY STATES.

NAME OF STATE.	STACKS HEARD FROM.	STACKS IN BLAST.	STACKS OUT OF BLAST.	STOCK ON HAND. NET TONS.	HANDS UNEM- PLOYED.
Maine.....	1	1	0	400	None.
Vermont.....	2	1	1	500	80
Massachusetts.....	2	1	1	536	45
Connecticut.....	7	6	1	3,632	78
New York.....	33	26	7	31,116	382
New Jersey.....	11	5	6	12,332	60
Pennsylvania.....	152	100	52	91,681	3,419
Maryland.....	15	12	3	10,801	673
Virginia.....	21	9	12	6,970	867
West Virginia.....	5	5	0	4,255	179
North Carolina.....	1	0	1	None.	60
Georgia.....	3	3	0	773	50
Alabama.....	8	6	2	6,249	210
Kentucky.....	11	8	3	12,150	300
Tennessee.....	12	6	6	9,615	500
Ohio.....	48	32	16	47,797	2,898
Indiana.....	7	0	7	10,378	500
Illinois.....	5	1	4	11,710	200
Michigan.....	18	12	6	21,254	666
Wisconsin.....	13	7	6	6,805	470
Missouri.....	10	6	4	19,476	885
Total.....	385	247	138	308,430	12,522

The report, furthermore, discusses at length the subject of tariff legislation, and relative topics of interest to the trade.

The American Iron and Steel Association.—At a recent meeting in Philadelphia, of the several independent organizations devoted to the iron and steel interests of the country, a union was effected between them, the consolidated body taking the name of "The American Iron and Steel Association." Such a union of forces can not be otherwise than favorable to the cause they represent. The report of the Secretary at the same meeting, contained a strong appeal for the formation of a scientific section of the Association, which should in its operation develop those features which have made the British Iron and Steel Institute so valuable. The report states that it was declared to be necessary, in the organization of the Association, to discuss practical and scientific subjects bearing upon the manufacture

and working of iron and steel; but that thus far, owing to a combination of unfavorable circumstances, this scientific phase of the Association has not received its proper share of attention. Now, however, that all conflict of interests has been effaced by consolidation, the reorganized body should, and doubtless will, strive to make it as representative of scientific metallurgy in America, as is its sister association of such progress abroad.

A Chord of "Spheral Music."—BY PLINY EARLE CHASE.*—In various communications to the American Philosophical Society, I have pointed out simple harmonic relations between planetary distances, which seem to indicate a tendency to cosmical aggregation at harmonic nodes, in a vibrating elastic medium.

In a paper, read on the second of May last, I introduced the harmonic series, $\frac{7}{2}$, $\frac{7}{10}$, $\frac{7}{18}$, $\frac{7}{26}$, $\frac{7}{34}$, of which the unit is the earth's mean-radius vector. Finding representatives for the other terms, I stated that the term " " represents "a possible unknown planet, planetoid group, or other seat of solar and planetary perturbation." By Kepler's law the cyclical period of such a perturbation would be about 51 days. I also suggested the Wolf's sun-spot period of 27 days "might be readily explained by the perturbations and transits of a planetoid or meteoric group, at a distance which would complete the terrestrial harmonic series."

Professor Winlock kindly allowed me to examine the measurements of the sun's spotted area, at the observatory of Harvard University. They indicated such a periodicity as I was looking for, but as the observations covered a period of less than five months, I did not regard them as conclusive.

I subsequently found in "Nature," of July 17th, an abstract of a communication to the Royal Society on June 19th by Messrs. De La Rue, Stewart and Loewy, who find evidences of a tendency in sun-spots "to change alternately from the north, or positive, to the south, or negative hemisphere, and *vice versa*," and "*that the two outbreaks are at opposite ends of the same solar diameter.*" Their inferences are drawn from observations taken in three different years and covering an aggregate period of 407 days. Their lowest approximate estimate of the mean interval between two maxima in the same solar hemisphere is 22.25 days; the highest, 28 days; "the most probable mean

* Read before the American Association for the Advancement of Science, Portland Meeting, 1873.

value, 25.2 days." The interval between two maxima of the same sign and originating at the same axial extremity would, of course, be twice as great.

Herschel (following Bianchi and Laugier), Spörer, Carrington and Faye, give estimates of the suns sidereal rotations varying between 24.62 and 25.33 days. The evidence, therefore, seems conclusive, both of a cycle due to solar rotation, and of another, due to some disturbing influence which revolves around the sun in a period approximately equivalent to two rotations.

The half-periods, being all made sidereal, and the corresponding mean distances, compare as follows :—

	Days.	Distance.
Spörer,	24.62	.263
Carrington,	24.97	.265
Faye,	25.07	.266
Wolf,	25.14	.267
De La Rue, Stewart and Loewy,	25.20	.267
Herschel, Bianchi and Laugier, .	25.32	.268
Harmonic prediction,	25.51	.269

Smithsonian Meteorological Observations.—From the sub-joined letter it will be observed that the Institution formally transfers the system of meteorological observations, continued through many years, to the Signal Service Department. This transfer will doubtless be for the best interests of science, while it is a handsome acknowledgement of the services of the Signal Service.

SMITHSONIAN INSTITUTION, WASHINGTON, D. C., 2d February, 1874.

To the Voluntary Meteorological Observers who have reported to the Smithsonian Institution :

It has been from the first a part of the policy of this Institution to devote its energies to no field of research which can be as well cultivated by other means ; and the United States Government having established a system of meteorological observations, and having made appropriation for its support, we have thought it for the best interest of the science to transfer the system of meteorological observations which has been so long continued by the institution to that of the War Department, under the Chief Signal Officer, Gen. Myer.

The propriety of this transfer will be evident from the fact that the Institution has not the means of paying for printing blanks, postage, and the calculations and monthly publication of the results, and that the assistance which has heretofore been rendered, in this way, by the Department of Agriculture is now discontinued ; furthermore, Gen. Myer can combine these observations

with those made with standard instruments now under his charge, and out of the whole form a more extended and harmonious system than any at present in existence.

We trust this transfer will meet the approbation of the observers generally, and we hope they will continue their voluntary coöperation—not with the expectation of being fully repaid for their unremitted labor, in many cases for a long series of years, but from the gratification which must result from the consciousness of having contributed to increase the sum of human knowledge. We trust also that the observers will continue to cherish an interest in the welfare and progress of the Smithsonian Institution, while, on our part, we shall in all cases and at all times, be pleased to continue to answer any communication which may be addressed to them on scientific subjects.

We shall retain for the present all the records of observations which have been accumulating at the Institution during the last twenty-five years, and continue the work of their reduction and discussion up to the end of the year 1873.

The investigations relative to the rain up to 1866 have been published, and a supplement will be published giving the results since that time.

The temperature investigations are nearly finished, and those relative to the winds will be completed in the course of a month or two. The publication of the results will be made as rapidly as the means at our command will warrant. It is scarcely necessary to say that copies of these works will be distributed to all observers who have contributed the materials upon which these researches are based.

Very respectfully,

Your obedient servant,

JOSEPH HENRY,

Secretary Smithsonian Institution.

The Coagulability of Serum and Albumen.—Messrs. Mathieu and Urbane have recently presented some novel and important facts relative to the above heading in a paper read before the French Academy. They assert that if the gases dissolved in the serum of the blood are completely removed, an albuminous liquid is obtained, which does not coagulate even at a temperature of 212° . The same fact was found to hold good with egg albumen when the gases were removed therefrom by suitable pneumatic apparatus. Further investigation, according to the authors, demonstrated the fact that the greater portion of this gas consists of carbonic acid, and that it is really to the presence of this that the property of coagulation is to be ascribed. It was found to be possible, furthermore, to restore the property of coagulating by heat to albumen thus treated, by simply introducing into it a sufficient quantity of carbonic acid.

It is quite probable that the ability to remove the coagulability of albumen by extracting the carbonic acid which it contains, and to re-

store it, by supplying it by artificial means, may be found to be of value in many industrial operations in which albumen is employed.

Mineral Cotton.—Under the heading of “A new Incombustible and Non-conducting Material,” the “American Artisan” makes reference to an article presented at the Vienna Exposition by an establishment at Osnabrück, to which, from its peculiar qualities and its origin, the name of *slag-wool* (*schlackenwolle*) is applied. This material, it is further stated, is made from the slag of a cupola furnace, by directing upon it in its fluid state, as it runs from the furnace, a strong jet of steam, by which treatment the slag is thrown, in the condition of fine fibres, into a cast iron chamber or receptacle, from which it is gathered in a form resembling wool. It is further stated that experiment has shown it to be an excellent non-conductor, on which account a variety of uses are predicted for it. Especially is it recommended as a coating for steam pipes, about which it is stated it may be wrapped, without reference to bends, angles or convolutions, with the same facility with which wool itself could be applied.

By reference to the files of this journal,* our readers will perceive that this material has been known for some years in this country, and its application as a non-conductor of heat, secured by letters patent, although it has not been introduced into general use. The statement of our contemporary concerning the admirable non-conducting qualities of the material is quite correct. It was first presented to the notice of the public, at the stated meeting of the Franklin Institute in November, 1871, by the President (Mr. Coleman Sellers), and from the subsequent report of the Committee of Science and the Arts, to whom it was submitted for examination into its merits, it was found to have quite superior non-conducting qualities, as indeed might be predicted from its nature, and from the great quantity of air which its feathery condition permits it to retain.

The extreme brittleness of the material, however, renders doubtful the assertion that it may be successfully applied to steam pipes or boilers, without some cementing material like lime, or other artifice, to retain it permanently in place. So brittle is it, indeed, that it readily breaks up into the finest spiculæ, which at the least disturbance fill the air, and make it quite unpleasant to handle it even for a short time.

* Vol. lxvi, p. 361.

Phosphor-Bronze.—We have referred to the results of experimental trials with the new alloy, “phosphor-bronze.” We observed that the phosphor-bronze had been employed to advantage for the great bearings of the plates in general rolling mills, and for conical gearing in universal rolling mills, in cases where the rollers weighed five tons. It was found that the gear, when made of hard cast-iron, broke frequently; this was replaced by wheels of ordinary bronze, and finally by wheels of phosphor-bronze. The duration of the ordinary bronze wheels did not exceed, on an average, five months, while those made of phosphor-bronze lasted for about nine months. The phosphor-bronze has also been applied not only in the making of pinions but in the driving axles of mills; in the latter case the superiority seems to depend not on the hardness, but upon the very great resistance of the alloy. To form a just idea of the value of this remarkable substance, no better evidence could be offered than the estimate placed upon it by the several juries in the mechanical department of the Vienna Exposition, where it obtained the following awards, viz.: In group 1, for cog-wheels, tuyeres, and bearings, the diploma of merit; in group 7, for revolvers and parts of harness, the medal of progress; and in group 12, for its application to guns and other material, the medal of merit. Unlike other alloys, it can be remelted without any material loss or deterioration of quality; while heavy steel castings on the other hand, when worn out or broken, are comparatively worthless. A great variety of objects hitherto worked in iron and steel may now be cast in phosphor-bronze with advantage, and in many cases they required only a polish to make them ready for use; in addition to which they possess the merit of not corroding. Its great fluidity, compactness, and fine grain, as likewise its beautiful color, are qualifications which adapt it eminently for decorative art, and the perfection of the castings materially reduces the cost of subsequent chasing and finishing. The phosphor-bronze alloys made for railing, drawing, or embossing, will stretch more than copper, or any of its ordinary compounds. Plates have been reduced by a single cold rolling to one fifth their thickness, the edges remaining perfectly sound and without crack. Another advantageous property of the new alloy resides in its incapacity to emit sparks. Tools, knives, scissors, and other articles, such as locks, keys, etc., have on this account already been largely adopted by manufacturers of gunpowder.

Several governments have experimented on the new alloy as to its adaptability for making cannon. Without exception the result showed

a much greater resisting power than that displayed by ordinary bronze. In Prussia it was shown, in firing with the regulation charges, and diminishing at each fifty shots the exterior diameter of the chamber, that the phosphor-bronze cannons changed their dimension only when the thickness of the metal was below that of the dimensions of a cannon of the same calibre of steel. The Belgian government has adopted the phosphor-bronze for small arms and for the harness metal of its cavalry. From the brief space of time it has been before the mechanical world, not less than from the modifications of which its physical properties are susceptible by slight variations in its constitution, it is fair to presume that the uses to which it may be advantageously applied have as yet by no means been fully recognized.

Deposits in Boiler Flues.—Concerning the formation of deposits in boiler flues, about which a considerable amount of speculation has been published, Prof. Hayes give the following opinion in a late issue of the *American Chemist*: These are of two kinds, both of which are capable of corroding the iron rapidly, especially when the boilers are heated and in operation. The most common one consists of soot (nearly pure carbon) saturated with pyroligneous acid, and contains a large proportion of iron if the deposit be an old one, or very little iron if the deposit has been recently formed. The other has a basis of soot and fine coal ashes (silicate of alumina) filled with sulphur acids, and containing more or less iron, the quantity determined by the age of the deposit. The pyroligneous deposits are always caused by want of judgment in kindling the fires. The boiler being cold, the fires are generally started with wood; pyroligneous acid then distills over into the tubes, and collecting with the soot already there from the first kindling fires, forms the nucleus for the deposit, which soon becomes permanent and more dangerous every time wood is used in the fire-place afterwards. The sulphur acid deposits derive their sulphur from the coals used; but the base, holding their acid, is at first occasioned by cleaning or shaking the grates, soon after adding fresh charges of coal. Fine ashes are thus driven into the flues at the opportune moment for them to become absorbents for the sulphur compound distilling from the coals, and the corrosion of the iron follows rapidly after the formation of these deposits.

The Centennial Exposition.—It is the proposition of the United States Centennial Commission to make a portion of the buildings necessary for the Exposition of 1876 a permanent structure, which will be called Memorial Hall, and shall always remain as a commemoration of the great event. It is designated for use during the exhibition as the Art Gallery, and eventually as a National Art Museum.

As it will be built with funds especially contributed for that purpose by the State of Pennsylvania and the City of Philadelphia, the approval of the design was vested in the State Board of Supervisors, a body appointed by the State Legislature.

The architects are Messrs. Collins and Autenreith, of Philadelphia, who obtained the first prize in the final competition.

The building will be located on the Landsdowne Terrace, immediately north of the main pavilion, with which it will be connected by a wide covered approach or corridor 175 feet long.

Our cut represents a view from the northwest side, as seen from the drive at the foot of the terrace, after the temporary buildings are removed.

The general outline of the plan of the proposed building is a cross with arms respectively 420 feet and 320 feet long; width of each, 123 feet; average height above the floor, 70 feet. A dome rises from the intersection, and four towers which appear clear and complete in outline from the ground up. From the top of the figure on the dome to the level of the terrace is 284 feet.

It is proposed to use stained glass for the windows of the dome, and to use the central rotunda as a general resort for visitors, and not for exhibition space.

Four large stairways lead out from the rotunda up to the galleries.

The basement is to contain retiring rooms, boilers for heating, and ample offices for the Park police; there is likewise an entrance for heavy teams carrying marbles, bronzes, etc., and in two of the towers elevators for the proper distribution of such articles upon the different floors.

Bibliographical Notices.

Wheeler's Natural History Charts.—Prof. C. Gilbert Wheeler, of the University of Chicago, has issued a series of five charts, very correctly and handsomely illustrating the following subjects: Mammalia, Birds, Amphibians and Fishes, Intervertebrates and Minerals, Rocks and Fossils.





THE CENTENNIAL EXHIBITION, PHILADELPHIA, 1876. THE PROPOSED MEMORIAL HALL.

The charts contain upward of 700 illustrations, in which the natural colors of the various objects are faithfully given. The plates are lithographed and carefully and laboriously colored by hand, a mode of execution confined almost exclusively to the scientific monographs or the publications of learned societies. The animals have a life-like and animated appearance, and the minerals are faithfully reproduced, with their natural luster. In addition to leading fossils, and stratigraphical geology, there are a large number of special illustrations of crystallographic forms. Each chart is made up of five sheets of plates, fourteen by twenty-four inches, with two columns of text, running the whole length of the chart. This text, though concise, is fully descriptive, and, with some additional matter, is published in book form. Now, that natural history has become so important and indispensable a branch of education, and that every teacher is bound to pass an examination in that specialty, the possession of charts such as these will prove very desirable in schools and public institutions.

We particularly commend them to the notice of teachers in country towns, where facilities for obtaining the specimens usually stored in museums are not available. The publishers are A. S. Barnes & Co., Chicago and New York.

Editorial Correspondence.

AN ACCOUNT OF A STEAM BOILER EXPLOSION.

Editor of the Journal of the Franklin Institute :

DEAR SIR.—The following account of a very destructive steam boiler explosion, which occurred about six months ago, is not only valuable for the completeness and reliability of the facts connected with it, but instructive in its results. It is derived from the notes of an able ex-engineer of the Navy, who witnessed it from the distance of a few hundred yards.

The boiler was built of the best quality of iron, about the year 1854, by McCarter Brothers, of Norristown, for Mr. John Wood, of Conshohocken, Pennsylvania, for use in his rolling mill. It was cylindrical, 44 inches in diameter, and 24 feet in length, with two interior cylindrical flues of 16 inches diameter each. The thickness of the iron in the shell was originally five-sixteenths of an inch, but at the time of the explosion it was only three-sixteenths of an inch. The thickness of the iron in the flues was originally three-eighths of an inch, but at the time of the explosion it was less than one-quarter of an inch. The heads of the shell, originally, were conical, but had become nearly flat. The seams of the entire boiler were single riveted with rivets of five-eighths of an inch in diameter.

This boiler was connected with several others by one main steam-pipe, and was heated by the escaping gas from a puddling furnace. It, like those, was provided with a separate stop-valve, gauge-cocks and safety-valve, but had no separate pressure-gauge; there being

but one steam-gauge for all, and that was attached to the main steam pipe. The safety-valve was adjusted to a pressure of 80 pounds per square inch above the atmosphere, but nothing is known as to its fitness for use, or whether or not it was rusted to its seat. The latter supposition appears probable.

The boiler, on Saturday, had been shut off from the others by the closing of its stop-valve, and blown out, while they continued in use. On the Monday following, it was well filled with water, and the hot gas from a puddling furnace in full action was turned into the flues. No water was admitted after the hot gas was turned in, and no steam withdrawn either by escape from the safety-valve, or by use in the engines, for the stop-valve was allowed to remain closed, and the engineer states that no steam blew off at the safety-valve up to the time of the explosion. There being no steam-gauge on the boiler, the only indication of the great pressure within it was the unusual violence with which the water was observed to rush from the gauge-cocks just previous to the catastrophe.

The conditions, at the instant of the explosion, were then as follows: The boiler was well filled with water. The generation of steam was as rapid as an abundant supply of highly-heated gas from a puddling furnace could produce. The steam thus generated had no escape.

The explosion which quickly followed this combination of circumstances was tremendous in the extreme. The boiler was torn asunder in the middle, and one-half hurled about 300 feet, passing through a 2-foot thick brick wall into an iron tank weighing many tons, which it dislodged to a considerable distance. The boiler-flues were flattened, like a board, from end to end. The sheets of the boiler shell were rent through the solid metal in many places, while in others the fracture was through the rivet holes, and in still others the rivets were sheared. A considerable portion of the boiler was torn literally to shreds, and everything surrounding it demolished. The building containing it was made a complete wreck; not a boiler, puddling furnace, pipe, wall or column was left standing within a radius of 200 feet.

The explosion was unquestionably caused by a gradually, but *very rapidly*, accumulating pressure to beyond the boiler's strength of resistance. The accumulation was so rapid that both flues and shell simultaneously yielded—the one to compression, the other to extension—and the various fractures of the iron, in some places through the solid sheet, in others through the rivet holes, and in others by the shearing of the rivets, were mainly due to the suddenness of the ruptures, there being very little time for the stretching of the metal, or its gradual yielding, or slow transmission of strain.

I am of opinion that the phenomena of steam boiler explosion are much modified by the *rapidity* with which the pressure increases to the exploding point; and that the destructive capability of such explosions bears a very decided relation to this fact.

Very truly yours, B. F. ISHERWOOD,

Chief Engineer U. S. Navy.

Civil and Mechanical Engineering.

[Entered according to the act of Congress, in the year 1873, by John Richards, in the office of the Librarian of Congress at Washington.]

THE PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

BY J. RICHARDS, Mechanical Engineer.

(Continued from page 34.)

BELTS FOR TRANSMITTING POWER.

The traction of belts upon pulleys, like that of locomotive wheels upon railways, being incapable of demonstration except by experience, hindered for a long time the introduction of belts as a means of transmitting motion and power. I mention motion separately because with many kinds of machinery that involve high speed, such as wood machines, the transmission of rapid movement must be considered as well as power, and it is only by means of belts that such high speeds may be communicated from one shaft to another; so that at least in practice, belts alone are at this time employed for high speed.

The first principle I will point out in regard to belts, distinguishing them from shafts as a means of transmitting power, is that the power is communicated by means of tensile instead of torsional strain, the power during its transmission being represented in the difference of tension between the driving and the slack sides of the belts.

In the case of shafts, their length, or the distance to which they may be extended in transmitting power, is limited by torsional deflection, and as this torsional strain is avoided with belts, we may conclude that, unless there are other disqualifying conditions, belts are better than shafts for transmitting power through long distances.

Belts suffer resistance from the air and from the friction in the bearings of supporting pulleys, which are necessary in long horizontal belts. With these exceptions they are capable of moving at a high rate of speed and transmitting power without appreciable loss.

Following this proposition into modern engineering practice, we find how experience has gradually conformed to what these properties in belts would suggest; wire and other ropes with a diminished cross section to avoid air friction, and allowed to droop in low curves to avoid supporting pulleys, are now commonly employed for transmitting

power through long distances. This system has been very successfully carried out in Germany and America, in some cases for distributing power in large manufacturing establishments.

Belts, among which are included all flexible bands, do not afford the same facilities for taking off power at different points that shafts do, but have advantages in transmitting power to portable machinery, or, in other words, when the power is to be taken off at movable points, as in the case of travelling cranes, hoists and so on.

An interesting example in the use of belts for communicating power to movable machinery is furnished in the travelling cranes of Mr. Ramsbottom, in the shops of the L. & N. W. Railway, at Crewe, England, where powerful travelling cranes receive both the lifting and traversing power by means of a cotton rope not more than one inch in diameter, which moves at a high velocity, the motion being reduced by means of tangent wheels and gearing to attain the force required in lifting heavy loads. In looking at this mechanism, those who had not their conceptions based on a true knowledge of power and the relations between power and speed, would see, in the effect of this small cotton rope, something marvellous.

Considered as means for transmitting power, the contrast as to advantages and disadvantages lies especially between belts and gearing instead of between belts and shafts. It is true in extreme cases, such as that cited at Crewe, or in conveying water power from inaccessible places through long distances, and so on, the comparison lies between belts and shafts, but for ordinary practice, in three cases out of four, the problem as to mechanism for conveying power is between belts and gearing.

If experience in the use of belts was thorough, as it is in the case of gearing, and if the quality of belts did not form an important part in the estimates, there would not be much difficulty in determining where belts should be employed and where gearing would be preferable.

Belts are continually taking the place of gearing even in cases where they have been until very recently thought inadmissible; at least one of the largest rolling mills in Pittsburg, Pennsylvania, except a single pair of spur wheels as the last movers at each train of rolls, is driven by belts throughout.

Leaving out the matter of a positive relative movement between shafts, which belts as a means of transmitting power cannot insure,

there are the following conditions that must be considered in determining whether belts or other means should be employed in transmitting power :

1. The distance to which the power must be carried.
2. The speed at which the transmitting machinery must move.
3. The course or direction of transmission, whether in straight lines or at angles.
4. Durability and the cost of construction.
5. The loss of power during transmission.
6. Noise, vibration and jar.

In every case where there can be a question as to whether gearing shafts or belts will be the best means of transmitting power, the several conditions named will furnish a solution if properly investigated. Speed, noise or angles may become determinative conditions, and are such in a large number of cases ; first cost and loss of power are generally secondary conditions.

Applying these tests to cases where belts, shafts, or wheels may be employed, and carefully considering the special conditions of any case, the apprentice will soon find himself in possession of knowledge to guide him in his own plans and enable him to judge of the correctness of examples that come under his notice.

It is never enough to know that any piece of work is generally constructed in some particular manner, or that such a proposition is generally accepted as being correct ; nothing is learned, in the true sense, until the reasons for it are understood, and it is by no means sufficient to know from observation alone that belts are best for high speeds, that gearing is best to form angles in transmitting power, or that gearing consumes more power, and that belts produce less jar and noise ; the reasons for these things and the principles that lie at the bottom must be reached before it can be assumed that the subject is understood.

GEARING AS A MEANS OF TRANSMITTING POWER.

The term gearing, which was once applied to wheels, shafts and the general mechanism of mills and factories, has now in common use become restricted to tooth wheels, and is in this sense employed here.

Gearing as a means of transmitting motion is employed when the movement of parts of machinery must remain relatively the same—when a heavy force is transmitted between shafts that are near to each other, or when shafts are at angles to each other.

This rule is of course not constant, except as to cases where positive relative motion is essential ; noise and the liability to sudden ob-

struction may be reasons for not employing tooth wheels when the distance apart and the position of shafts would render such connection the most durable and cheap.

Gearing under ordinary strain, within limited speed and when other conditions admit of its use, is the cheapest and most durable mechanism for transmitting power, yet the amount of gearing employed in machinery, especially in Europe, is no doubt far greater than it will be in future and as belts are better understood.

No subject belonging to mechanics has been more thoroughly investigated than that of gearing; text-books are replete with every kind of information pertaining to gearing, at least so far as the subject can be made a mathematical one, and to judge from the amount of matter, formulæ and diagrams relating to the form of teeth that the apprentice will meet with, he will no doubt be led to believe that the main object of modern mechanics is to generate the teeth of wheels. It must be admitted that the teeth of wheels and the proportions of wheels is a very important matter to understand, and should be studied with the greatest care, but it is equally important to know how to produce the teeth in metal after their configuration has been defined on paper; to understand the endurance of teeth under abrasive wear when made of wrought or cast iron, brass or steel; how patterns can be constructed from which correct wheels may be cast, and how the teeth of wheels can be cut by machinery, and so on.

The learner should, in fact, consider the application and operative conditions of gearing as the main part of the subject, and the geometry and construction of wheels as subsidiary, and based upon the operation of wheels.

Gearing consists of spur wheels, bevel wheels, tangent wheels, spiral wheels and chain wheels; the last I include among gearing because the nature of their operation is analogous to tooth wheels, although at first thought such chains seem to correspond to belts.

The motion imparted by chains that mesh over the teeth of wheels is positive, and not frictional as in belts. The speed at which gear chains may run, with other conditions, corresponds to gearing.

Tangent wheels as a name is certainly as applicable, and to be preferred to worm wheels, for the class of gearing to which it belongs. As all these forms of gearing can be seen in almost any engineering establishment, and in view of the amount of scientific information relating to wheels that is available to the apprentice, it will only be necessary here to point out some of the conditions that govern the use and operation of wheels.

The durability of gearing, aside from breaking, is dependent upon the amount of rubbing action that takes place between the teeth when in contact; spur wheels or bevel wheels, when the pitch is accurate and the teeth of the proper form, if kept clean and lubricated, wear but little, because the contact between the teeth is that of rolling instead of sliding.

Tangent wheels and spiral gearing have only what is termed line contact between the bearing surfaces, and as the action is a sliding one, such wheels are subject to rapid wear and are incapable of sustaining much pressure, or transmitting a great amount of power, except the surfaces be hard and lubrication constant.

In spiral gearing the line of force is at an angle of forty-five degrees, with the bearing faces of the teeth and the sliding movement equal to the speed of the wheels at their periphery; the bearing on the teeth, as before said, is one of line contact only; such wheels cannot be employed except in cases where an inconsiderable force is to be transmitted.

For communicating movement to the beds of planing machines, or to racks of any kind, the rack can be drawn to the wheel and a lifting action avoided by shortening the pitch of the rack, so that it will vary a little from the driving wheel; the rising or entering teeth in this case do not come in contact with those on the rack until they have attained a position normal to the rack.

HYDRAULIC APPARATUS FOR TRANSMITTING POWER.

Although a system but recently invented, the use of hydraulic machinery for transmitting and applying power has reached an extended application to a variety of purposes, and gives promise of a still more extended use in future.

Considered as a means of transmitting regularly a constant amount of power, water apparatus is more expensive and inferior in every respect to belts or shafts, and its use must be traced to some special principles involved that adapt hydraulic apparatus for the performance of certain duties.

These principles will be found to consist in storing up power in such a manner that it may be used with great force at intervals, and, secondly, in the facilities afforded for multiplying motion or force by the use of pumps.

An engine of ten horse-power, that is connected with machinery by hydraulic apparatus, may exert a force equal to one hundred horse-

power for one tenth of the time, the power being stored up by accumulators in the interval, or, in other words, the motive power acting continuously can be accumulated or stored up and applied at intervals as it may be required for raising weights, operating punches, compressive forging, or other work of an intermittent character. Hydraulic machinery employed for such purposes is more simple and inexpensive than gearing and shafts, especially in the application of a great force acting for a considerable distance, and where a cylinder and piston represent an amount of strength that could not be gained with twice the amount of detail if screws, levers, or other devices were employed instead.

Motion or power is varied to almost any degree by the ratio between the pistons of the pumps and the pistons that give off the power; the same general arrangement of machinery answering in all cases, whereas with gearing the quantity of machinery has to be increased as the difference between the motive power and the applied power increases; this recommends hydraulic apparatus where a great force is required at intervals, and it is in such cases that it was first applied, and is yet for the most part used. In the use of hydraulic apparatus for transmitting and applying power there is, however, this difficulty to be contended with: water is inelastic and non-yielding, and, in the ordinary machinery for performing irregular duty, there is a loss of power equal to the difference between what a piston can perform and what it does perform, that is, the amount of water, and consequently the amount of power given off, is as the movement, instead of as the work that is performed. This applies to cases where accumulators that store up the power by lifting weights, are used but not to accumulators where the power is stored by compressing air, or in cases where steam pressure acts directly against the water that performs the work; in such cases the consumption of steam is in proportion to the amount of force employed. In the latter case the water in its relations to the motive power and the work is the same as shafts or gearing, merely a medium of regular transmission. The application of hydraulic force to the lifting and handling of weights will be noticed under another head.

PNEUMATIC MACHINERY FOR TRANSMITTING POWER.

Pneumatic machinery, aside from the subtlety and elasticity of air as compared with water, is analogous in operation to hydraulic machinery.

Water may be considered as a rigid medium for transmitting power, and air as a flexible or yielding one, the first corresponding in some respects to gearing and the latter to belts.

There is at this time but a limited use of pneumatic apparatus for transmitting power, but its application is rapidly extending, especially in the way of transporting materials by means of air current and in conveying power to mining machinery.

The successful application of the pneumatic system at the Mont Cenis tunnel in Italy, and at the Hoosac tunnel in America, has demonstrated its value in such operations, where the air not only serves to transmit power to operate the machinery but to ventilate the mines at the same time.

Pneumatic force is also used for sinking foundations, and in some cases for lifts and hoists. Presuming that the flow of air in pipes is not materially impeded by friction or angles, and that there will be no difficulty in maintaining lubrication in pistons or other machinery driven by air, there seems to be many reasons in favor of its use as a means of distributing power in manufacturing districts.

The diminished cost of power when generated on a large scale, and the expense and danger of maintaining a steam power for each establishment, especially in cities, points to many advantages in generating and distributing power as gas and water are now supplied.

Air seems to be the most natural and available medium for transmitting and distributing power upon any general system like water or gas, and there is every probability of such a system existing at some future time. There is no subject more interesting, and perhaps none more important for an engineering student to study at this time, than the transmission of power and transport of material by pneumatic means. The power given out by the expansion of air is not equal to the power consumed in compressing it, but the loss is but insignificant compared with the advantages that may be gained by its use in many cases.

In considering pneumatic machinery there are the following points to which the attention of the apprentice is directed:

The value of pneumatic apparatus in reaching places where steam furnaces cannot be used.

The use that may be made of the exhausted air after it has been applied as a motive agent.

The saving from condensation, to which steam is exposed, avoidance of heat, and the consequent contraction and expansion of conducting pipes.

The loss of power by friction and angles in the flow of air through pipes when carried to long distances.

The lubrication of surfaces working under air pressure, such as the pistons and valves of engines.

The diminished cost of generating power, on a large scale, compared with a number of separate steam engines distributed over manufacturing districts.

The effect of pneumatic machinery in reducing insurance rates and dangers of fire, as compared with steam machinery.

The investment in the appliances of distribution and their maintenance.

In passing thus rapidly over so important a subject, and one that admits so extended a consideration as machinery of transmission, the reader can see that the purpose has been to touch only upon such points as will lead to thought and investigation, and especially to meet the queries that arise in the mind of a learner.

In arranging and erecting machinery of transmission, obviously the first problem must be, what kind of machinery should be employed? And, secondly, what are the conditions that should determine the selection and arrangement? What has been written has, so far as possible, been directed to the proper means of solving these questions.

MACHINERY OF APPLICATION.

The term application, has been selected as a proper one to distinguish machines that expend and apply power from those that are employed in generating or transmitting power. Machines of application expend their action on material, and are directed to certain operations, which I will term processes, such as cutting, compressing, grinding, separating and disintegrating.

By classifying these processes, it will be seen that, after all, but a few functions are to be performed by machines, and that they all act upon a few general principles.

For instance, all engineering tools used in fitting are directed to the process of cutting. Planing machines, lathes, drilling machines, and shaping machines are all cutting machines, acting upon the same general principles.

Confining what is said, for the present, to machines of application that have cutting action, it may be assumed that the operation of such machines is governed by certain principles or laws, and that the most thorough manner of studying and understanding the nature

operation and best mode of their operation, manner of constructing such machines, is by a study of these laws or principles.

Cutting, as an operation, includes the force to propel cutting edges, and means to guide and control their action. In cutting with hand tools, the operator performs these functions of propelling and guiding the tools with his hands, and in power operations the machines do the same; but to be of value, machines must either employ more force than a man can exert, or must guide the tools with greater accuracy than is attainable by hand.

Increased speed may also be an object in the employment of machinery, as well as the guidance of cutting edges, or increased force in propelling them; in other words, the hands of an operator are not only limited as to the power that may be exerted, but also as to the rate of movement, which becomes a highly important consideration in many operations where neither the force or guidance of tools are wanting.

There is nothing more interesting, nor at the same time more useful, in the whole study of mechanics, than to analyze the action of cutting machines or other machinery of application, to ascertain whether the main object of a machine is increased force, more accurate guidance, or greater speed than is attainable by hand operations. Cutting machines may be directed to either of these objects singly, or to all of them together, or these objects may vary in their relative importance in different operations, but in all cases the general principles remain the same.

To follow this matter further, we find in such machines as are directed mainly to augmenting force or increasing the amount of power that may be applied to any operation, such as sawing wood or stone, the effect produced when compared to hand labor, is nearly as the difference in the power applied, and the saving that such machines effect is generally in the same proportion. A machine that can expend ten horse-power in performing its work, will save ten times as much as a machine that expends but one horse-power, provided the purpose of the machine is to perform operations in which hand labor lacks power.

In other machines of application, where they are directed mainly to guidance or speed of action, such as sewing machines, dove-tailing machines, gear cutting machines, and so on, there is no relation whatever between the advantages gained and the amount of power expended.

The difference between hand and machine operations and the labor saving effect of machines, will be treated in another place ; the subject is alluded to here, only to enable the reader to more fully distinguish between machinery of transmission and machinery of application.

Machinery of application directed to what has been termed compression processes, such as steam hammers, drops, presses, rolling mills, and so on, act upon material that is naturally soft and ductile, or when it is softened by heat, as in the case of forging.

The nature of compressive operations of all kinds is distinguished from cutting and abrading, in the fact that no material is cut away, the mass being forced into shape by dies or forms that give the required configuration.

The action of compressing machines may be either intermittent, as in the case of rolling iron, or percussive, as in steam hammers, where a great force acts throughout a limited distance.

Machines for abrading or grinding are common among machinery of application, their main purpose being to cut or shape material that cannot be heated, and is too hard to be acted upon by compression or by cutting processes.

Separating machines, although forming a distinct class, such as bolting and screening machines for grain, are not complex enough to require explanation.

Grinding, no doubt, if traced to the principles that lie at the bottom, is nothing more than a cutting process, in which the edges employed are harder than any material that can be made into cutters, and in which these edges are firmly supported by being imbedded into a mass like the particles of sand in grindstones, or the particles of emery in emery wheels.

Disintegrating machinery, as a class, includes machines directed to grinding grain, or separating the fibres of textile material, such as grinding mills, pulp machines, cotton and wool machinery.

The principle of action in machines of this class requires no special explanation here ; the process is one of crushing, tearing and macerating.

To be continued.

METHOD OF ASCERTAINING WHAT PORTION OF THE FEED-WATER ADMITTED TO A BOILER IS ENTRAINED IN THE FORM OF SPRAY BY THE ESCAPING STEAM.

By Chief Engineer ISHERWOOD, U. S. Navy.

In making tests of the evaporative efficiency of boilers, it is desirable to know what fraction of the feed-water admitted to the boiler during an experiment is vaporized, and what fraction in the form of spray is mingled with and entrained by the steam.

This problem is very difficult to solve correctly, requiring costly apparatus; precise measurements of large quantities of water; thermometers absolutely accurate, for a very slight error in the temperatures would be equivalent to a very considerable error in the two fractions of the feed-water to be ascertained; and boilers perfectly free of leakage under the pressure employed.

The apparatus needed is a tank for the measurement of the feed-water previous to admission in the boiler; a condenser, in which all the steam generated in the boiler is condensed, and the temperature of the resulting water together with that of the water entrained in the form of spray, is reduced to the temperature of the feed-water; and a tank for the measurement of the condensing water previous to its use in the condenser. The condenser and the steam-pipe connecting it with the boiler, are to be covered with felt or other non-conducting substance, and placed in a temperature midway between that of the steam and that of the condensing water after use, as any heat lost or received by the steam and entrained water after leaving the boiler, would vitiate the results. Placing the condenser and steam-pipe in a temperature midway between that of the steam entering and that of the condensing water leaving the condenser, neutralizes, as nearly as possible, the effect of external temperature; and clothing them, additionally, with a non-conducting substance, reduces this effect to a minimum.

The pressure under which the generation and condensation of the steam take place must be identical, and the initial temperature of the feed-water must also be identical with the final temperature of the condensing water, in order to eliminate the transformation of heat into work which would otherwise be caused by the displacement of different pressures, due to the difference of bulks resulting from the difference of temperatures.

The principle of the investigation is simply a comparison of the quantity of heat that would have been imparted to the feed-water in the boiler, had all the feed-water been vaporized, with the quantity of heat (experimentally ascertained) imparted to the condensing water by the condensation of the steam and the reduction of the temperature of the resulting water, together with that of any water which may have been entrained in the form of spray, to the initial temperature of the feed-water.

Let w be the weight of feed-water admitted to the boiler ;

t^0 , the temperature of the feed-water ;

t^1 , the temperature of the steam ; and

h , the heat of vaporization above the temperature t^0 . Also, let W be the weight of condensing water used ;

T^0 , the temperature of the condensing water before use ; and

T^1 , the temperature of the condensing water after use. Finally,

let w be the weight of feed-water in the form of spray, having the temperature t^0 entrained by the steam ; then .

$w - w^1$ is the weight of feed-water vaporized.

$$\text{And } (w - w^1) \times h + w^1 \times (t^1 - t^0) = W \times (T^1 - T^0).$$

$W \times (T^1 - T^0)$ represents the total quantity of heat, experimentally ascertained, imparted to the feed-water in the boiler, which quantity is composed of the unknown quantity $(w - w^1) \times h$, consumed in vaporizing the weight $w - w^1$ of feed-water, and of the unknown quantity $w^1 \times (t^1 - t^0)$, consumed in raising the temperature of the weight w^1 of feed-water from t^0 to t^1 . The determination of the values of w and of $w - w^1$ in fractions of w is the object of the following process.

The specific heat of the water is supposed to be constant at all its temperatures, which is not quite true ; the correction, however, would be so insignificant that it has been omitted, to avoid unnecessary complication. It can be easily made, if required, by simply multiplying the weights of water at the different temperatures by the respective specific heats and taking the products as the weights in place of the original weights of water.

It is obvious that the quantity $W \times (T^1 - T^0)$, as experimentally found, will equal $w \times h$ in the case in which all the feed-water is vaporized. It can never be greater than $w \times h$, but may easily be

less by the entrainment of part of the feed-water with the steam, and less in proportion as the quantity so entrained is greater. This results from the fact that the heat of vaporization of a given weight of feed-water is much greater than that which is required to raise its temperature from t° to t°_1 .

In the single case in which the temperature of the feed-water is the same as that of the steam entraining a portion of it in the form of spray, the fraction vaporized of the feed-water is the fraction which the experimental quantity $W \times (T^{\circ}_1 - T^{\circ})$ is of the quantity $w \times h$; that is, this fraction will be the quotient of $\frac{W \times (T^{\circ}_1 - T^{\circ})}{w \times h}$, the remaining fraction of the feed-water having been entrained in the form of spray, but, not having had any heat imparted to it in the boiler, does not enter as a factor in the computation. For example: Suppose the temperature t° of the feed-water and t°_1 of the steam to be 212° Fahrenheit; the heat h of vaporization, 965.7 Fahrenheit units; the weight w of the feed-water admitted to the boiler, 1 pound; the weight W of condensing water, 5 pounds; the temperature T° of the condensing water before use, 50° Fahrenheit; and its temperature T°_1 after use, 212° Fahrenheit. Then $\frac{5 \times (212^{\circ} - 50^{\circ})}{1 \times 965.7} = 0.83877$ = the fraction vaporized of the feed water, while the fraction entrained in the form of spray by the steam is $(1.00000 - 0.83877) = 0.16123$.

But in all other cases of the entrainment of feed-water, in which its temperature is less than that of the steam, the experimental quantity of heat $W \times (T^{\circ}_1 - T^{\circ})$ is composed of two unknown quantities $w \times (t^{\circ}_1 - t^{\circ})$ and $(w - w_1) \times h$, the first being the quantity of heat imparted to the entrained water, and the last being the quantity of heat imparted to the vaporized water. Hence, considering the entire weight w of feed-water admitted to the boiler as unity,

$$\frac{(w \times h) - W \times (T^{\circ}_1 - T^{\circ})}{h - (t^{\circ}_1 - t^{\circ})} = w_1 = \text{the fraction of the entire feed-}$$

water admitted to the boiler, which has been entrained in the form of spray by the steam. Consequently, $w - w_1 = 1 - w_1$ = the fraction of the entire feed-water admitted to the boiler, which has been vaporized.

From the above formula may be derived the following rule for ascertaining the proposed results: From the quantity of heat which would have been imparted to the feed-water admitted to the boiler, had it *all* been vaporized, deduct the quantity of heat which was imparted as experimentally given by the increased temperature of the weight of condensing water used, and divide the remainder by the latent heat of the steam; the quotient will be the portion, in terms of the unit of weight employed, of the feed-water entrained in the form of spray by the steam. The subtraction of this quotient from the weight of feed-water admitted to the boiler gives the portion, in terms of the unit of weight employed, of the feed-water vaporized.

The above formula is based on the following reasoning: $w \times h$ is the quantity of heat that would have been imparted to the feed-water had it all been vaporized. $W \times (T^1 - T^0)$ is the quantity of heat that was imparted to the feed-water as experimentally ascertained. The latter quantity subtracted from the former leaves the quantity of heat due to the non-vaporization of a portion of the feed-water, which had been heated, however, to the temperature of the steam. The division of this remainder by the latent heat of the steam gives the weight of water, in terms of the unit employed, which was not vaporized, and which, consequently, was entrained in the form of spray by the escaping steam. The expression $h - (t^1 - t^0)$ is the latent heat of the steam. The following is a numerical application of the formula:

Suppose, for example, the entire weight w of feed-water admitted to the boiler to be 1 pound; the heat h of vaporization above the temperature t^0 of the feed-water to be 1078.5 Fahrenheit units; the weight W of the condensing water to be 19.637 pounds; the temperature T^0 of the condensing water before use to be 50° Fahrenheit; and its temperature T^1 after use to be 100° Fahrenheit; the temperature t^0 of feed-water to be 100° Fahrenheit; and the temperature t^1 of the steam to be 212° Fahrenheit. Then

$$\frac{(1 \times 1078.5) - 19.637 \times (100^\circ - 50^\circ)}{1078.5 - (212^\circ - 100^\circ)} = 0.1 = \text{the fraction of the entire feed-water admitted to the boiler which has been entrained in the form of spray by the escaping steam.}$$

Consequently $1 - 0.1 = 0.9$ = the fraction of the entire feed-water admitted to the boiler which has been vaporized.

GIRARD AVENUE BRIDGE.

By R. HERING, C. E. Assistant Engineer in charge, and T. C. CLARKE, C. E.

This bridge which is now under process of construction by the firm of Clarke, Reeves & Co., for the City of Philadelphia, was put under contract one year ago to-day, and is to be completed on the 22d September, 1874.

It crosses the Schuylkill river on the line of Girard Avenue, and will always be the chief entrance to the West Park, and during the Centennial Exhibition it will be the principal avenue of approach to the buildings.

Under these circumstances, it was considered that its dimensions should be ample, and that in solidity of construction, and in elegance of decoration, it should be surpassed by none.

Its principal dimensions are as follows :

Total length,	1,000 feet.
“ width,	100 “
Number and size of spans,	2 of 137, and 3 of 197 “
Length of side walk,	865 “
Number of piers, 4, abutments, 2	
Width of roadway,	67½ “
“ “ each side walk,	16½ “
Greatest height from roadway to rock foundation	85 “
Number of square feet of surface,	100,000 “
Cost per foot,	\$14 86.

Foundations.—The foundations of this bridge are constructed according to that system, first applied in this country on a large scale to bridge foundations at the Mississippi bridge at Quincy. That is to say, instead of pumping out the water by coffer-dams, or forcing it out by the use of compressed air, the water is not removed, but the material is dredged out, and when the rock is laid bare, it is covered with concrete, lowered through the water in an iron box, specially contrived to deposit it without washing out the cement. All the foundations were put in in this way, except that of the eastern pier, which was put in by a coffer-dam, and pumped out in the usual way. This was done in this special case, on account of the foundation being upon the site of an old timber and stone wharf which could not have been easily removed under water.

The foundation of the western shore pier was enclosed by a dam of 12 × 12" sheet piling, driven to the rock. The clay was then removed

by a dredge shaped like a pair of clam-shells, and finally cleaned by the rotary pump, and the concrete laid on the bare rock.

The foundations of the two central piers were formed by sinking a double-walled bottomless caisson, 34 feet wide \times 156 feet long, down upon the rock, which was first cleaned by dredging and divers. The spaces between the sides were filled with rough stone. The interior space was then cleaned by divers, using a rotary pump, which sucked up all the soft material, leaving the rock bare. The concrete was then lowered down, and its upper surface levelled off 18 feet below water. The masonry was then built and sank in an ordinary water-tight caisson.

Not the slightest sign of settlement or cracking has shown itself. The concrete moulds itself when soft to the irregularities of the rock bottom and hardens into a monolith, so that settlement is impossible if the concrete has been properly made. In the present case, the load thrown upon the concrete when new does not exceed 30 lbs. per square inch, and it is capable of resisting 300 lbs per square inch.

The materials employed were : Portland, Rosendale, Coplay, Allen, and Old Lehigh Cements, sharp river sand, coarse, screened gravel, and broken furnace slag. Of these, seventeen samples, each of a different proportion, were carefully mixed and kept under water 30 days. After that time they were tested with the following results :

The Rosendale cement had entirely failed, perhaps on account of its not being fresh when used. Its qualities have lately been very unreliable, and it was therefore rejected. The Portland cement, as was expected, acted by far as the best. The Coplay and Old Lehigh showed nearly equal strength, and the Allen gave the weakest specimen. Later, more careful comparisons between the Coplay and Old Lehigh cements proved that the former was somewhat the strongest, and much quicker in setting, therefore best adapted for subaqueous work.

Further, nearly all samples containing gravel, which held a considerable amount of loam adhering to it, broke with an entirely insufficient weight, and this material was therefore also rejected.

The furnace slag, crushed to pass through a 2 inch mesh, proved highly satisfactory. Its hardness, its rough texture, the angular form of each piece, seem to make it well suited for the intended purpose. All samples prepared with it and an amount of cement mortar sufficient to fill the interstices were entirely satisfactory.

The Portland cement allowed over twice the quantity of sand and

slag to be mixed with it, to give the same strength as the Coplay cement.

It was also found that the proportion of voids to solid material in the broken slag, was exactly as 1 : 2.

From these results the following materials and proportions were selected :

1	{	1 part Coplay Anchor cement.
		1 " sharp river sand.
2	{	4 " furnace slag.

The strength of this concrete was 308 lbs per square inch, after 30 days insertion in water. The extreme pressure per square inch on the foundation from bridge and heaviest load, will not be over 45 lbs.; we may therefore feel assured of its efficiency.

The concrete was mixed by hand on platforms, until each stone seemed to be coated with mortar, and was then lowered in a box, so contrived as to protect it from wash during its descent, and easily discharge it when touching bottom.

Masonry.—The masonry of the four piers is made of granite from the Maine quarries of Blue Hill and Buck's Harbor, from which came the granite for the piers of Saint Louis' bridge, and a portion of that for Brooklyn bridge.

It is a hard stone, of a rather light color and medium grain, the Buck's Harbor being the coarser of the two.

The abutments are made of Port Deposit granite, with quoins of a darker stone from the Bellevue quarries on the line of the Philadelphia and Baltimore Railway. The copings and parapets are of fine cut granite from Blue Hill quarries.

The specifications under which this masonry was constructed were as follows :

"The quoins shall be of dimension stone in courses from 16 to 32 inches high, heaviest at bottom and diminishing gradually towards top. They will be cut with a rock or quarry face and have 1" chisel draft, and chamfers $1\frac{1}{2}$ " wide \times 1" deep on the horizontal and vertical end joints, and will project 2" beyond face of wall; will also have chisel draft $1\frac{1}{2}$ " wide down each side of nose. They will be clamped with $\frac{3}{4}$ " round bars covered with coal tar to above high-water mark.

"The side walls between end quoins shall be built of quarry-faced ashlar, pitched to the proper lines. Courses same height as quoins. Headers not less than one and a half times the depth of course for face length, and depth in wall double face length. There shall be one

header to every two stretchers. Stretchers from four to seven feet long, and as much bed as rise. All stones to be sound and free from imperfections, to be dressed true and parallel on beds, so as to lay to a $\frac{3}{8}$ " joint. Vertical joints to be square with face for six inches back. Courses should bond on those below, a distance generally not less than depth of course, and in no case less than 12 inches.

"Backing either of concrete or suitable stone, not over two courses of backing to one of face. All face stone must be laid by tackle and lewis, and in mortar composed of one part of fresh ground Lehigh cement to two parts clean sharp sand.

"When directed, the joints shall be picked out, and properly pointed in cement with a rounded tool."

Superstructure.—The form adopted for the superstructure is the quadrangular girder, as usually made at Phoenixville. The upper chords and posts are Phoenix columns, united by cast-iron joint blocks. The lower chords and diagonal bars are Phoenix weldless eye bars. There are seven trusses, placed side by side, 16 ft. apart, and united by horizontal bracing. Upon them are laid heavy 15-inch Phoenix rolled beams, and upon these are laid longitudinally 9-inch rolled beams, placed 2' 8" apart. These will be crossed again transversely by rolled iron plates $\frac{1}{4}$ of an inch thick, corrugated 1 $\frac{1}{2}$ inches deep by 5 inches wide, as per specimen submitted.

The bridge and moving load of 100 pounds per square foot makes a total load of 30,000 pounds per lineal foot carried by seven trusses, equal to 4,286 pounds per lineal foot on each, or about three times that of an ordinary railway truss of similar span.

The limit of strain is ten thousand pounds per square inch of section, reduced to 6,000 pounds as compressive limit of posts, and 7,500 pounds shearing strain on pins.

All the points of contact are turned or planed, and the limit of error is $\frac{1}{16}$ of an inch. The iron is double refined, or Phoenix "Best Best," capable of bearing the regular tests as follows:

Ultimate strength,	55,000 to 60,000 lbs. per □"
No permanent set under,	25,000 to 30,000 " "
Average reduction of area at heating,	25 per cent.
Elongation of bar,	12" long, 15 per cent.
Cold bend,	180°

The whole bridge is on a regular camber of 18 inches, and the east end is 2 feet higher than the west end.

Considerable discussion took place at the time of awarding the con-

tracts for the construction of this bridge, as to the relative merits of iron arches and girders with parallel top and bottom members. The public eye has been educated to delight in the graceful curves of an arch, and it was with some reluctance that this form was given up.

For a stone bridge there can be no doubt but that the arch is both constructively and æsthetically correct. For an iron bridge it is not constructively correct in this climate of extreme variations of temperature, which would throw strains of more than double those resulting from the changes of temperature of the more even climate of Europe.

What the Arabian proverb says of stone construction is peculiarly applicable to an iron arch—"The arch never sleeps."

It is true that all these evil effects can be prevented by dividing the arch into two parts, and hinging it at the centre, and at each point of springing. But this is reducing the depth at the centre to nothing, and the arch, although perhaps strong enough, is not stiff, and will vibrate under a passing load.

As the authorities did not wish to be under the necessity of putting up a sign, "No trotting allowed on this bridge," they preferred to abandon the idea of arches and use parallel girders, whose stiffness is undoubted.

As you well know, expansion is provided for in girders by fixing one end to the pier and placing the other on rollers, leaving it free to move without causing any strain on the iron. In order that this movement might not interfere with the permanence of the roadway, the longitudinal beams are not attached to the floor beams upon which they rest, so that the main girders expand and contract independently of the floor system. The longitudinal beams are "fished" together with oval-holed plates, like a railway track, so that the movement is not accumulative. Upon these beams are laid, but not fastened, the corrugated iron floor plates.

These plates will be covered with asphalt concrete, so as to form a perfectly water-tight surface over the whole bridge. Upon this will be laid sand, and then granite blocks, forming the usual Belgian pavement, such as is used on Market and Broad streets, except that it will be divided into seven roadways by as many double lines of tram-ways, made of cut granite stones one foot wide and laid five feet apart.

These will not be sufficiently raised above the general surface of the pavement to interfere with crossing diagonally or "turning out,"

but being smoother than the rest can be made, will allow teams to glide over the bridge with the least possible noise and vibration.

The gutters and curb stones on either side will be of fine cut granite.

The sidewalks will have ten feet of their width made of black Lehigh county slates, laid in diagonal squares about 2 ft. \times 2 ft. On each side there will be a row of bright borders, made of Maw & Co.'s encaustic tiles. Inside will be the curb stone 18" wide.

The sidewalks will be divided from the roadways by railings of galvanized iron tubes with bronze ornaments, supported by cast-iron standards every six feet. At about every forty-eight feet the standard will be prolonged into a lamp post. On each of the eight refuge bags there will be clusters of lamps, treated in a highly ornamental manner.

There will be an outer balustrade and cornice of a highly ornamental design, containing panels of bronze, designed to represent birds and foliage. There will be about ten different patterns, arranged so that they will be repeated not oftener than sixty feet apart. There will be about a third of a mile of these bronzes set in the balustrade like pictures in a frame.

The whole treatment of this part of the bridge is believed to be original and different from any existing structure. It will form one of the contributions to the Centennial Exhibition of 1876 of the city of Philadelphia, and will probably be seen and criticised by the highest artistic knowledge in the world.

Architectural Decoration.—Great public works have been executed in all ages of the world, but it was not until the early part of the last century that their builders were divided into two distinct professions, called architects and civil engineers. At this time the line of division is very marked, and the results of this separation have, in many instances, not been productive of happy results from an artistic point of view.

Architecture has been well defined to be the art of decorative and decorated construction, that is to say, grace embodied in the structural contrivance, and grace superadded in the shape of ornament.

There can be no satisfactory architecture without both of these things. The first is indispensable; for unless the lines and proportions of the structures are good, no amount or richness of ornament can make it pleasing. On the other hand, the pleasing effect of good proportion and outline can be seriously marred by the injudicious application of ornament.

Engineering proper deals only with construction. It often happens

that an engineer will design a bridge, for example, to be built in some inaccessible place on a line of railway, and he will think ornament a useless expense. The subtle laws which govern the proportions of bodies placed to resist static forces will govern the shapes, and mould them in such a way that the plain, unadorned structure is pleasing to the eye of taste.

The same engineer, however, having another bridge to build, will think it necessary that it should be ornamented. Not understanding the true principles of decoration, he will cover his structure with sham arcades, and hang up rows of impossible pilasters resting on nothing.

Recognizing the danger of falling into this mistake, the designers of Girard Bridge have called into counsel the aid of professionally educated architects, the Messrs. Sims, members of the American Institute of Architects.

In designing the purely decorative features of this bridge, these gentlemen have been guided by the following principles :

1st. That there should be no sham ornamentation, no concealment of parts, and no effort to make one thing look like another. The ornament is merely an emphasizing or accentuating the prominent lines of construction.

2d. Each kind of material is allowed to suggest for itself its appropriate treatment, so as to show what it is. For example, iron is made to look like iron, and not like stone or wood.

3d. Color will be relied on to do what nature uses it for—to distinguish parts from one another.

Thirteen months have passed since this bridge was put under contract, and eleven since construction began. During this time a temporary bridge, 1050 feet long and 50 feet high, has been built; the foundations and masonry of the permanent structure have been completed, and the iron work has been made and erected.

It now only remains to complete the roadway, and it is hoped that this will be done in time to open the bridge for traffic several months before the date for completion of September 21, fixed in the contract.

When it is considered that this structure, although less than a quarter of mile long, contains as much material as is in a mile and a half of single track railroad bridge of similar spans, we can at least say that there has been no unnecessary delay so far.

The general dimensions of this bridge and the character of its materials were fixed by Samuel L. Smedley, Esq., Chief Engineer of the city of Philadelphia, under whose superintendence the whole works have been carried out.

RAILWAY CROSSINGS AND TURNOUTS.

BY C. A. EVANS, Civil Engineer.

Laying switches on railroads has, at present, to a very great extent, passed out of the hands of the engineer into those of the track master. The reason for this change is a simple one. The track master can, by his eye and a little experience, put down a switch, over which a train will pass apparently with ease, thus seeming to dispense with the mathematical data of the engineer. This is a bad practice, notwithstanding its universality; for, necessarily, the switch of the track master will be irregularly curved. It will therefore wear unequally, and finally be worn out at some point, often at the frog, before it has performed the full duty which a regular curvature would ensure. In a large yard, where there is much drilling and a heavy wear and tear in consequence, good switches are a matter of importance.

With a view to aid the engineer in laying out his switches quickly and with little calculation, whether on a straight line or on a curve, tables are here appended for this purpose. The formulæ by which these tables have been calculated are more numerous than those usually given in field books. This difference is owing to improvements in the arrangement of switches. Improvements have, in this case, as in many others, complicated the work. As it would not be proper to give the tables without the formulæ, the author will now proceed to establish these. It is preferable to treat separately the case of switches on straight lines from that of switches on curves, although the formulæ of the former may be deduced from those of the latter. Throughout the following investigations we will employ this notation, viz.:

g = gauge of tracks.

d = throw of switch rail.

l and l' = tangents passing through the point of the frog.

b = distance between tracks, including widths of both rails.

R and R_1 = radii of the centre line of the switch.

X = distance from point of frog to end of switch on the first branch.

Y = distance from the same to the other end of switch, measured on the same rail, on the second branch.

S = switch angle.

F = frog angle.

The problem of crossings and turnout to parallel tracks presents

itself in the following form: Given the frog angle, F , to find the distances, X and Y , the radii, R and R_1 ; and on curves, the other frog angle F^1 . Commencing with the *crossing on a straight track*, we have from Fig. 1:—

$$\overline{BF} = 2(R + \frac{1}{2}g) \sin \frac{1}{2}(F - S) = \frac{g - d - l \sin F}{\sin \frac{1}{2}(F + S)}$$

Therefore, we have, to obtain R :—

$$R + \frac{1}{2}g = \frac{\frac{1}{2}(g - d - l \sin F)}{\sin \frac{1}{2}(F - S) \sin \frac{1}{2}(F + S)} = \frac{g - d - l \sin F}{\cos S - \cos F} \quad (1)$$

For X we have:—

$$X = \frac{g - d - l \sin F}{\tan \frac{1}{2}(F + S)} + l \cos F. \quad (2)$$

We have from the triangle \overline{GQI} and the sector \overline{PEG} :

$$l^1 \sin F = b - d - (R - \frac{1}{2}g)(\cos S - \cos F.)$$

Hence:

$$l^1 = \frac{b - d - (R - \frac{1}{2}g)(\cos S - \cos F)}{\sin F} = \frac{b - d}{\sin F} = \frac{2(R - \frac{1}{2}g) \sin \frac{1}{2}(F - S) \sin \frac{1}{2}(F + S)}{\sin F}. \quad (3)$$

The value of R_1 is evidently equal to that of R .

We will now consider the *turnout on a straight track*. In this case we employ for the first branch eqs. (1) and (2), then assume, if desired, the value of l , and proceed to calculate the radius R_1 and the distance Y . For this last purpose substitute in eqs. (1) and (2):

$$R + \frac{1}{2}g = R_1 - \frac{1}{2}g, \quad l = l^1, \quad g = b^1, \quad S = o, \quad d = o,$$

and we have:

$$R_1 - \frac{1}{2}g = \frac{b^1 - l^1 \sin F}{2 \sin^2 \frac{1}{2}F} = \frac{b^1 - l^1 \sin F}{1 - \cos F} \quad (4)$$

$$Y = \frac{b^1 - l^1 \sin F}{\tan \frac{1}{2}F} + l^1 \cos F. \quad (5)$$

Next in order comes the consideration of the *crossing on a curved track*. Whether the switch turns to the inside or outside of the curve is a matter of indifference, as the values of the unknowns are independent of the direction of the switch on the curve. In Fig. (2) we will commence with the upper branch. To find the distance X , we need find only the angle:

$$\overline{OKR} = \overline{OKF} + \overline{FKR} = K^1 + K.$$

The first of these angles is obtained from the triangle $\overline{O K F}$, having given :

$\overline{O F} = l$, $\overline{O K} = R_o - \frac{1}{2} g$, and the included angle $\overline{K O F} = 90^\circ + F$

$$\left. \begin{aligned} \text{Therefore, } \tan \frac{1}{2} (\overline{K F O} - K^1) &= \frac{R_o - \frac{1}{2}(g-l) \tan \frac{1}{2}(90^\circ - F)}{R_o - \frac{1}{2} g + l} \\ \text{which with: } \frac{1}{2} (\overline{K F O} + K^1) &= (90^\circ - F) \end{aligned} \right\} \quad (1)$$

gives us also the angle $\overline{K F O}$.

$$\text{We may also write: } \overline{K F} = (R_o - \frac{1}{2} g - l) \frac{\sin \frac{1}{2} (90^\circ - F)}{\sin \frac{1}{2} (\overline{K F O} - K^1)} \quad (2)$$

Passing now to the triangle $\overline{B K F}$, we have given :

$$\overline{B K} = R_o + \frac{1}{2} g - d, \overline{K F},$$

and we can deduce expressions for the opposite angles in terms of K and other angles. Thus :

$$\overline{B F K} = \overline{B F E} + \overline{E F K} = S + \overline{K B F} + 90^\circ - \overline{K F O}, \overline{K B F}$$

$$\text{Hence: } \cot \frac{1}{2} K = \frac{\tan \frac{1}{2} (S + 90^\circ - \overline{K F O}) (R_o + \frac{1}{2} g - d + \overline{K F})}{R_o + \frac{1}{2} g - d - \overline{K F}} \quad (3)$$

$$\text{We have therefore: } X = 2 (R_o - \frac{1}{2} g) \sin \frac{1}{2} (K + K^1) \quad (4)$$

Also: $\overline{B F K} + \overline{K B F} = S + 2 \overline{K B F} + 90^\circ - \overline{K F O} = 180^\circ - K$,
from which: $\overline{K B F} = \frac{1}{2} (90^\circ - K - S + \overline{K F O})$, and, consequently,

$$\overline{B F} = (R_o + \frac{1}{2} g - d - \overline{K F}) \frac{\cos \frac{1}{2} K}{\sin \frac{1}{2} (S + 90^\circ - \overline{K F O})} \quad (5)$$

Passing next to the isosceles triangle $\overline{E B F}$, we have :

$$\overline{E B F} = \overline{K B F} + S = \frac{1}{2} (90^\circ - K + S + \overline{K F O})$$

$$\text{which leads to: } R + \frac{1}{2} g = \frac{\frac{1}{2} \overline{B F}}{\cos \frac{1}{2} (90^\circ - K + S + \overline{K F O})} \quad (6)$$

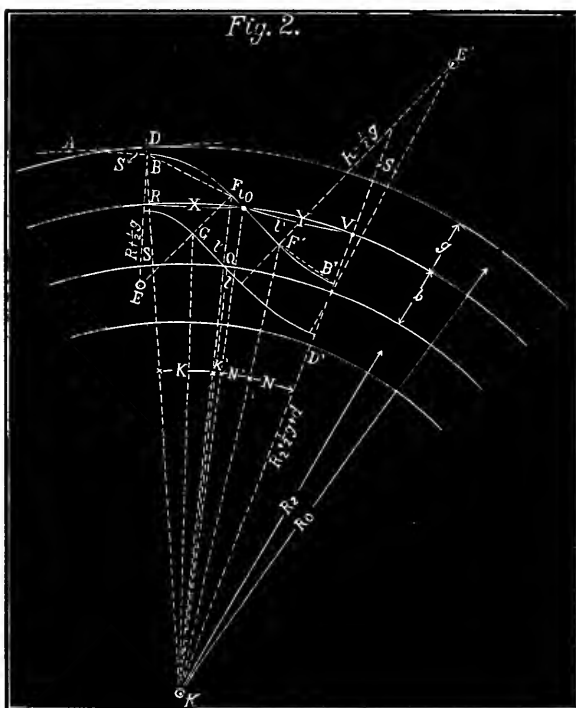
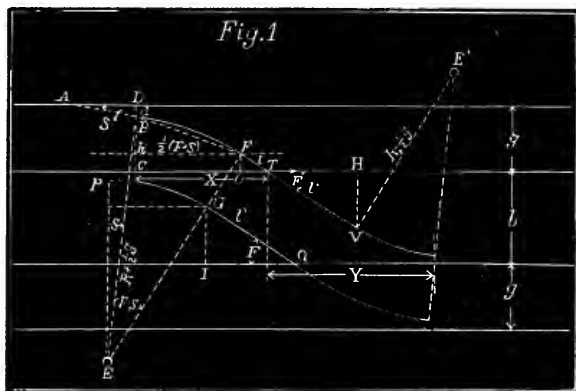
To obtain the value of l^1 we have in the triangle $\overline{K G F}$;

$$\overline{G F} = g, \overline{K F} \text{ as calculated, } \overline{G F K} = 90^\circ - \overline{K F O},$$

and consequently for the other angles :

$$\left. \begin{aligned} \tan \frac{1}{2} (\overline{F G K} - \overline{G K F}) &= \frac{(\overline{K F} - g) \tan (45^\circ + \frac{1}{2} \overline{K F O})}{\overline{K F} + g} \\ \frac{1}{2} (\overline{F G K} + \overline{G K F}) &= 45^\circ + \frac{1}{2} \overline{K F O} \end{aligned} \right\} \quad (7)$$

$$\text{Also, } \overline{K G} = (\overline{K F} - g) \frac{\sin (45^\circ + \frac{1}{2} \overline{K F O})}{\sin \frac{1}{2} (\overline{F G K} - \overline{G K F})} \quad (8)$$



TABLES.

No. 543 Frog (old No. 10), $F=5^{\circ} 43' 31''$.

Curva- ture of track.	X	Y	l	l'	R	R_1	$F'=GQK-90^{\circ}$
	FT.	FT.	FT.	FT.	FT. CURV'RE.	FT. CURV'RE.	° / ''
* 0°	56.94	82.88	5.00	31.08	960.39= 5° 58'	960.39= 5° 58'	5 43 31
1°	56.63	85.69	"	31.67	805.64= 7° 07'	1381.01= 4° 09'	5 28
2°	56.29	89.14	"	32.36	695.09= 8° 15'	2473.89= 2° 19'	5 11
* 3°	55.93	93.21	"	33.13	611.70= 9° 23'	11113.12= 0° 31'	4 53 53
4°	55.57	97.92	"	33.99	545.59=10° 31'	-4469.17= 1° 17'	4 35
5°	55.19	103.27	"	34.95	491.96=11° 40'	-1868.79= 3° 04'	4 15
* 6°	54.81	109.25	"	36.00	448.09=12° 50'	-1195.97= 4° 48'	3 53 47

No. 709 Frog (old No. 8), $F=7^{\circ} 09' 10''$.

	FT.	FT.	FT.	FT.	FT. CURV'RE.	FT. CURV'RE.	° / ''
* 0°	47.87	68.71	5.00	26.00	542.65=10° 34'	542.65=10° 34'	7 09 10
1°	47.58	70.34	"	26.37	487.13=11° 47'	661.74= 8° 40'	6 57
2°	47.30	72.17	"	26.74	442.25=12° 59'	849.32= 6° 45'	6 44
* 3°	47.04	74.22	"	27.10	405.87=14° 10'	1177.70= 4° 53'	6 30 41
4°	46.80	76.48	"	27.46	374.39=15° 21'	1899.76= 3° 01'	6 16
5°	46.56	78.94	"	27.80	348.11=16° 31'	4911.15= 1° 10'	6 02
* 6°	46.34	81.62	"	28.14	324.91=17° 40'	-8781.94= 0° 40'	5 48 22

No. 931 Frog (old No. 6), $F=9^{\circ} 31' 36''$.

	FT.	FT.	FT.	FT.	FT. CURV'RE.	FT. CURV'RE.	° / ''
* 0°	37.48	53.26	5.00	20.97	269.47=21° 23'	269.47=21° 23'	9 31 36
1°	37.31	53.90	"	21.13	254.68	298.54=19° 17'	9 22
2°	37.13	54.64	"	21.28	241.07	334.05=17° 13'	9 13
* 3°	36.97	55.48	"	21.42	228.67	378.59=15° 10'	9 03 49
4°	36.81	56.43	"	21.55	217.46	437.22=13° 08'	8 54
5°	36.64	57.48	"	21.68	207.43	516.24=11° 07'	8 44
* 6°	36.48	58.64	"	21.79	198.60	627.01= 9° 08'	8 34 37

In the triangle $\overline{K G Q}$ we have given :

$$\overline{K G}, \overline{K Q} = R_2 + \frac{1}{2} g, \overline{K G Q} = \overline{F G K} - 90^\circ.$$

$$\text{Hence : } \sin \overline{G Q K} = \frac{\sin (\overline{F G K} - 90^\circ) \overline{K G}}{R_2 + \frac{1}{2} g} \quad (9)$$

from which the angle $\overline{G Q K}$ may be deduced. Also :

$$\overline{G K Q} = 180^\circ - \overline{G Q K} - \overline{F G K} + 90^\circ = 270^\circ - \overline{G Q K} - \overline{F G K} \quad (10)$$

$$\text{Finally, } l^1 = \frac{\sin \overline{G K Q} (R_2 + \frac{1}{2} g)}{\sin (\overline{F G K} - 90^\circ)} \quad (11)$$

In order to obtain the value of Y for the second branch of the switch, we deduce first the angle $\overline{O K B^1} = N^1 + N$ from the triangles $\overline{O K F^1}$ and $\overline{F^1 K B^1}$. In the first of these triangles we have given :

$$\overline{O K} = R_0 - \frac{1}{2} g, \overline{O F^1} = l^1, \overline{K O F^1} = 90^\circ - F.$$

$$\text{Hence, } \tan \frac{1}{2} (\overline{O F^1 K} - N^1) = \frac{(R_0 - \frac{1}{2} g - l^1) \tan \frac{1}{2} (90^\circ + F)}{R_0 - \frac{1}{2} g + l^1} \quad (12)$$

$$\text{and, } \frac{1}{2} (\overline{O F^1 K} + N^1) = (\frac{1}{2} 90^\circ + F).$$

From which we have the angles $\overline{O F^1 K}$ and N^1 ; also

$$\overline{K F^1} = (R_0 - \frac{1}{2} g - l^1) \frac{\sin \frac{1}{2} (90^\circ + F)}{\sin \frac{1}{2} (\overline{O F^1 K} - N^1)} \quad (13)$$

In the second triangle $\overline{F^1 K B^1}$, we have given the sides :

$$\overline{K F^1}, \overline{K B^1} = R_2 + \frac{1}{2} g + d;$$

and the opposite angles :

$$\overline{F^1 B^1 K} = 180^\circ + S - \overline{F^1 B^1 E^1}, \overline{K F^1 B^1} = 270^\circ - \overline{O F^1 K} - \overline{E^1 F^1 B^1}$$

Hence we have :

$$\cos \frac{1}{2} N = \frac{\tan \frac{1}{2} (S + \overline{O F^1 K} - 90^\circ) (\overline{K F^1} + R_2 + \frac{1}{2} g + d)}{\overline{K F^1} - (R_2 + \frac{1}{2} g + d)} \quad (14)$$

$$\text{And, therefore, } Y = 2 (R_0 - \frac{1}{2} g) \sin \frac{1}{2} (N^1 + N), \quad (15)$$

To arrive at the value of the radius of the second branch of the switch, we have :

$$\overline{F^1 B^1} = (\overline{K F^1} - (R_2 + \frac{1}{2} g + d)) \frac{\cos \frac{1}{2} n}{\sin \frac{1}{2} (S + \overline{O F^1 K} - 90^\circ)} \quad (16)$$

$$\text{And, } \overline{F^1 B^1 E^1} = \frac{1}{2} (270^\circ + N + S - \overline{O F^1 K})$$

$$\text{Therefore, finally, } R_1 - \frac{1}{2} g = \frac{\frac{1}{2} \overline{F^1 B^1}}{\cos \frac{1}{2} (270^\circ + N + S - \overline{O F^1 K})} \quad (17)$$

We pass now to the *turnout on a curved track*. In this case we employ the foregoing formulæ with the following alterations: 1st, Whichever is the second branch of the turnout, we must place in the formulæ of the corresponding branch of the crossing in the foregoing:

$$S = o, \text{ and } d = o.$$

2d. The values of l and l' being assumed, we may omit the equations (7), (8), (9), (10) and (11).

These formulæ should be applied with the aid of logarithms, and employing the usual precautions in deducing small angles and those near 90° .

We pass next to an explanation of the tables. In calculating these the following values were assumed for the required quantities, viz. :

$$g = \text{gauge of track} = 4' 9'' = 4.75'.$$

$d = \text{throw of switch rails} = 5\frac{1}{2}'' = 0.458'.$ The switch rails are supposed to be $27' 0''$ long, with $7' 0''$ spiked fast, thus giving $20' 0''$ movable.

$$S = \text{switch angle} = 2^\circ 37' 27''; \text{ deduced from } \tan S = \frac{6.5''}{1200''}$$

$$l = 5' 0'' \text{ constant for all frogs.}$$

$$b = \text{distance between tracks, including widths of both rails} = 7' 4'' = 7.333'.$$

On examining these tables they will be found to be three in number, at the head of each of which is the angle of one frog of the switch, which angle is also an assumed quantity. It will be further noticed that these frogs are numbered differently from the old system, though belonging to it. The method here used is to write in one line the figures expressing the degrees and minutes of the angle of the frog. Thus a $5^\circ 53'$ is No. 543. To the engineer such a number is significative, and to the track master it as useful as No. 10. The numbers, according to this system of numeration, being large, are not easily remembered, and should, consequently, be placed on the frogs during manufacture. The change here indicated is necessary.

In the first column of the tables are the degrees of curvature of the centre line of the *tracks*, the radius of which is equal to $R_0 - \frac{1}{2}(b+g) = R_2 + \frac{1}{2}(b+g)$; while 0° signifies a straight track. The tables are carried up to 6° curves, but, if desired, the second in particular may be carried beyond. Or, curve above 6° degrees occurring rarely, a special calculation may be made for each case. In the last column are given the angles of the frogs working with those at the heads of the tables. All the nine cases marked with asterisks were

calculated by the preceding formulæ and with the use of Callet's logarithms. The intermediate cases were interpolated with the formula of interpolation—

$$f + nd_1 + \frac{n(n-1)}{2} d_2 + \frac{n(n-1)(n-2)}{2.3} d_3 + \&c.$$

As we had in the columns of each table three equidistant cases, we could employ this formula up to the third difference. In the majority of the columns the value of the second difference will be found to be small, which fact leads to the conclusion that the third difference would, in *all* the columns, be very small, and affect at the most only the second figures of the decimals in the columns by very little. We thus conceive that the interpolation must give results practically as good as the actual calculation by the formulæ. In the columns of R and R₁, we found, with a single exception, the degrees of the curves corresponding and interpolated by them in preference to interpolating by their radii. The negative values of R indicate that the curvature is the opposite of that of the positive values; or, in other words, both branches of the crossing curve in the same direction, towards the inside of the tracks. In the last column the interpolation has not been carried out to seconds, because such accuracy is neither necessary nor attainable without the third difference. *For curves lying between any two of those shown in the tables* we may obtain the required data by *ordinary* interpolation. Thus, if the data of a frog No. 543 is required for a 2° 09' curve, all we have to do is to find the difference between the figures of the 2° and 3° curves in each column of the proper table, and add or subtract $\frac{9}{60}$ of this difference from the data of the 2° curve, according as the column increases or diminishes in passing to its foot.

It is evident that if we strictly adhere to figures given in the last column we must have a frog for every few minutes of difference in the curvature of the tracks. This is quite impracticable. We are therefore obliged to make a close approximation to the requirements of theory. Let us diminish by 30' at a time, and to a certain extent the angles of the frogs at the heads of the tables. We have:

$$\left. \begin{array}{l} 5^\circ 43' - 0^\circ 30' = 5^\circ 13', \text{ No. 513.} \\ 5^\circ 13' - 0^\circ 30' = 4^\circ 43', \text{ No. 453.} \\ 4^\circ 43' - 0^\circ 30' = 4^\circ 13', \text{ No. 413.} \end{array} \right\} \text{Group No. 1.}$$

$$\left. \begin{array}{l} 7^\circ 09' - 0^\circ 30' = 6^\circ 39', \text{ No. 639.} \\ 6^\circ 39' - 0^\circ 30' = 6^\circ 09', \text{ No. 609.} \end{array} \right\} \text{Group No. 2.}$$

$$\left. \begin{aligned} 9^{\circ} 31' - 0^{\circ} 30' &= 9^{\circ} 01', \text{ No. 901.} \\ 9^{\circ} 01' - 0^{\circ} 30' &= 8^{\circ} 31', \text{ No. 831.} \end{aligned} \right\} \text{Group No. 3.}$$

The *greatest* inaccuracy which may arise by the use of any group of these frogs, instead of those indicated in the tables, is one of only $0^{\circ} 20'$ in the angle. To prove that such an approximation is allowable let us suppose a switch established with the exact frog as given in the last column. Consider, next, this frog to be removed and an approximate one to be placed in its position. The rails of the switch will not fit into the latter by a certain quantity, which is, *at the most*, very nearly:—

$$3.0 \times \sin 0^{\circ} 20' = 0.018 \text{ ft.} = \frac{1}{5} \text{ in. nearly;}$$

if we take the joint of the frog to be 3 feet from either extremity. It is plain that in a distance of 12 or 14 ft. from the frog along the tangents \overline{GQ} and $\overline{OF^1}$, each equal to l^1 , the rails may be gradually deflected either way from a straight line to an extent at the end of $\frac{1}{5}$ of an inch, in order to fit into the approximate frog, without involving in the alteration any prejudicial effect. Indeed, by going back a few feet more from the frog, we might introduce a greater deflection and make, consequently, the frogs of each set vary by $0^{\circ} 35'$ or $0^{\circ} 40'$. But there is no advantage in this change. On the other side of the frog it would be necessary, in order to be very accurate in making a fit, to change slightly either the value of R_1 from that given in the tables or that of S . Both these variations have effects so small, however, that in practice they may be neglected. We thus perceive that the only alteration consists of a slight bending of the straight l^1 , hardly noticeable, while the curved portions of the crossing remain circular arcs.

With a view to use the patterns of the old Nos. 6, 8 and 10 these frogs were placed at the heads of the tables. According to the preceding there would be required at least two, and at most seven new patterns. On large lines there can be no objection to having five and even ten patterns of frogs, if properly kept. Since Nos. 543, 709 and 931 are used more frequently, being employed double on straight track, twice as many of these may be manufactured as of the others.

We will give an explanation of the use of the tables in the field. The distances X and Y having been measured along the inner edge of the rail, we know, Fig. (2), the point of the frog O and the ends of the crossing D and D^1 . By the point of the frog is here understood, not the blunt point of it, but the intersection of the sides of its angle,

a point easily obtained on the frog itself. From the point of the frog along the tangent to the rail at its inner edge, or sensibly along the inner edge of the rail, measure five feet. Again, from the extremity of this distance, and from the point of the frog, find the intersection of the distances $10 \times \sin \frac{1}{2} F$ and 5 ft. This is the tangent point F of the inner edge of the rail of the crossing; and knowing its width at top and foot we may lay down the position of either edge of its foot, which point should be marked permanently with a stake and tack as usual. Since we know the throw of the switch-rails we may locate, similarly, the position of the same edge of the foot of the rail at the tangent point near B. The distance between these two tangent points, or the chord of the arc, being measured we may from the tables obtain the value of its radius, R, and consequently deduce three ordinates for the curvature of the rail. We thus have five points to locate the rail, and the accuracy of the location may be known by the edge of its foot passing through these points. The other rail of the crossing, opposite to the one thus determined should be laid by gauge. In order to determine the point R of the other frog, described from O, with a radius of

$$\sqrt{(l' - l)^2 + g^2},$$

an arc, which will cut the inner edge of the lower rail at the point required. By means of the value of R we may lay out in a similar manner, as before, the rail running from this point of frog to the other end D¹ of the crossing. If it is desired to commence at this end of the crossing we must first lay out the value of Y, and from O determine Q.

At the site of a crossing or turn-out the curvature of the track should be corrected, if necessary, before proceeding to lay it down.

It is not obligatory for both tracks to be in position in order to lay out the switch, as will be seen by examining the figures. If the rail along which X and Y are measured is not down, the point O can always be determined by the conditions of it being at a distance *b* from the inner edge of the rail beneath and at one end of Y, the other end of which is known, for it lies on a radius easily obtained through D¹. The point R is likewise determined from O; and knowing the curvature of the track, a perpendicular to it at R may be erected with an instrument by sighting on O and the points B and D determined.

The tangent $\overline{FO} = l$ may be laid down from O, since we know the angle of the frog. When the lower track is not in, the points B¹ and

D^1 may be ascertained by similarly erecting a perpendicular at V . The tangent l at Q , may be determined similarly to l at O .

A turnout may be regarded as a crossing in which the switch rails at one end are permanently fastened down. Hence if $b=7'-4''$ we may establish it just as a crossing, and with the aid of the accompanying tables.

The tables appended are calculated for a $4' 9''$ gauge, but they may be applied to a gauge of $4' 8\frac{1}{2}''$ with only a slight modification. To explain this change, suppose the upper and lower rails of the two tracks to be moved towards the centre line, each $\frac{1}{2}$ inch, which movement will cause the gauge in both tracks to be reduced to $4' 8\frac{1}{2}''$. Again, consider the lower rail of the crossing in the figures to be moved parallel to itself, the point of the frog F^1 continuing on the rail, until the gauge of the crossing is also reduced $\frac{1}{2}$ inch. The throw of the switch at the upper end or at the branch X is reduced to 5 inches, at the lower end or at the branch Y it remains $5\frac{1}{2}$ inches, and the value of l^1 is increased $\frac{1}{2} \cot F_1$ inches. This alteration in the value of l^1 will produce changes in the lower branch of the crossing, but these are easily seen to be inappreciable in practice. The crossing will, therefore, have on curves a throw, at the end further away from the centre of the curve, of 5 inches, and at the other end, of $5\frac{1}{2}$ inches, while on tangents the *positions* of these throws may be interchanged, remembering that the length of the branch for the 5 inches throw is X , and that the point of the other frog is determined by the formula :—

$$\sqrt{(l^1 - l + .042 \cot F^1)^2 + g^2}$$

which must be used also on curves to get the point of the frog F^1 . With the sacrifice of only a little accuracy we may adopt a uniform throw of $5\frac{1}{4}$ inches throughout for a $4' 8\frac{1}{2}''$ gauge. Hence we conclude, that the tables may be used for both gauges with no other change save that already introduced in the preceding expression for the $4' 8\frac{1}{2}''$ gauge.

The usual numbers of the frogs at present in use are, as we have already remarked, Nos. 543, 709 and 931, or, according to the old enumerations, Nos. 10, 8 and 6. It is evident that if to these frogs we add those of *either* group No. 1, No. 2, or No. 3, we will have in one case 6, and in the other two cases 5, as the *total* number of frogs necessary to enable us to lay out switches on straight lines and on curves up to 6° inclusive. Thus we perceive that we need add to the present number of frogs used only 2 more, to permit their accurate

use on curves. Still, there remain certain advantages appertaining to the employment of the whole 10 indicated. These advantages are founded on the great latitude of application which a system involving such a number of frogs possesses. At every point where it is proposed to establish a switch, a choice may be made between *three* differing in the curvature of their branches, in the angles of their frogs, in the total lengths of the crossings. That switch in which the frogs make the closest approximation to perfect work, might, therefore, be adopted. Should this condition happen to be fulfilled equally well by all, we might now govern our choice by selecting the switch in which the curvatures of the branches are gentlest. Again, in large yards, where many tracks and many crossings exist, we may be, though rarely it is true, limited in the length of a new switch to be put in. If we now have several from which to choose, we may pick out the most suitable switch for the locality. However, should it be thought better to provide for such cases as they present themselves, and we are willing to dispense with the previous advantages, as being most too refined, we may fall back on the number 5 as the necessary number of our frogs.

With the view of diminishing still further this number of frogs by employing on curves, as well as on straight lines, the three usual ones, it has been suggested to the author the employment of a larger curve to the second branch Y of the switch, that it may intersect the upper rail of the lower track at a required angle. Though the suggestion is not novel to him, yet it might be well to examine it. It is evident, Fig. (2), that if the curve of the lower branch commences above the point Q, it will cut the rail beneath at a *smaller* angle than the tangent \overline{GQ} . Now as we have no frog sharper than No. 10, it follows that this frog cannot be used on the upper branch of the switch, and in consequence, we are not able to deduce a table corresponding to the first of those here submitted. The discussion of the two methods will, therefore, be confined to a consideration of only the two last tables. When two curves are made to intersect at Q, then, in order to maintain symmetry in our switch, two curves should intersect at O as well.

In connection with this change we must notice that often the radius of one branch, and sometimes of both branches, of the switch are less than 300 feet; and to introduce a *straight* frog, though only 5 or 6 feet in length, for a corresponding length of curve given by such radii would, in practice, amount to flattening suddenly the curve in that short distance by between 0.1 and 0.2 inch—an appreciable

quantity. In the method given here we must replace a portion of only *one* curve by a straight piece; and remarking that the greatest curvature of this curve is not more than 6° , the straight frog, evidently, occupies sensibly the same position as the curve. Indeed, should the curvature of the track be even as much as 8° , there would still be no sensible difference.

Let us pass now to another point. The tangent $\overline{F F^1}$, Fig (2), will, if we pursue the method suggested, be diminished by not only 2 *l* or 10 feet, in virtue of the tangents *l* disappearing, but it will also suffer considerable diminution by the point of tangency F^1 commencing nearer to O. In all cases there will be very little straight track between the two branches of the switch. In a few other cases, *l*¹ will not be sufficiently large to allow the tangent point F^1 moving far enough back that the curve may intersect at Q at the requisite angle. For this reason it is extremely doubtful, if a No. 6 frog at O will allow, in any curve, up to about 2° , the introduction of a No. 8 frog at Q. The second table in this system will probably, therefore, not be as complete as the third for the system here developed. In conclusion, we may remark that, even in the possible cases of the system suggested, restricted as they are in number, there will be but very little straight line, and sometimes none, between the two branches of the switch; so that, at best, we are approximating closely to a reverse curve—a curve long discarded by engineers.

If we wish to confine ourselves to the employment of only *three* frogs, and still be able to lay out switches up to 6° curves inclusive, we may, instead of using the usual numbers, use only one of them, either No. 8 or 6 with the group corresponding, No. 2 or 3. This would amount to substituting for two of the usual frogs, two others with different angles. Such a system, though applicable to small lines, yet, as regards straight track, is too limited for large ones.

A New Photometer.—From the American Gas Light Journal we learn that a British patent has recently been granted to A. M. Webber for a method and apparatus for obtaining photometric measurements in terms of electrical measurements. A body, of which the electrical conductivity or resistance is altered by exposure to light, is placed in an electrical circuit, in which circuit there is also placed an electrometer, or gauge of electrical resistance. Light is directed on the body, and the value of this light, or the transparency or density of any translucent substance through which the light is passed, is tested by the effect on the electrometer or resistance gauge.

THE 'PRISMOIDAL' ONE RAIL RAILWAY.

A paper read before the Franklin Institute, January, 1874.

By E. CREW.

The assertion that a train of cars can be run upon one rail would seem like an impracticability. The first impression is that it would be *impossible* to keep it on the track, especially when turning short curves. Men of experience, and practical attainments as machinists, have expressed the opinion that this *must inevitably* be the case. It would be well to remember, however, that the first efforts to utilize *steam* as a motive power, were ridiculed and treated with contempt by those whose opinions were supposed to be sustained by knowledge. Less than thirty-two years ago, the idea of transmitting communications by telegraph, was ridiculed as the dream of a visionary, by the very men who claimed to be familiar with the laws of electricity.

It is remarkable that scientific men and those claiming distinction as inventors, should be so prone to discourage the efforts of others to perfect inventions, or develop some new theory in science. When the stereoscope was first introduced in France, it was submitted to five distinguished savants in succession, who could see, or pretended to see, nothing in the instrument worthy of attention. One week before the first steamship crossed the Atlantic, and arrived safe in an American harbor, Dr. Lardner, Professor of Natural Philosophy and Astronomy in University College, London, and a distinguished author of scientific works, pronounced ocean steamship navigation a failure; and while Mr. Røebling was building the Niagara Suspension Bridge, Sir Robert Stevens, a celebrated civil engineer and builder of light houses and bridges, declared at a banquet, that no suspension bridge could be built that would carry a train over it. Such examples should teach humility and charity. It is unsafe for any man, however learned, to assume that other men, even of modest pretensions, may not know more than he does concerning the very question upon which he assumes to be so dogmatical.

The attention of the writer, some four years since, was first given to the task of endeavoring to cheapen transportation. In the commencement of his deliberations, he took an unprejudiced view of the efforts that had been made, up to 1868, in this direction, by means of balloons and air-ships. The balloon, he considered, if ever made available between distant points, could never build up a line of communications with intermediate stations, with that regularity and cer-

tainty that now characterizes railroads and renders them indispensable to almost every community. For this reason, he decided to give no time or expense in attempts in that direction, but rather to a compromise line between balloons and two-rail railroads in such a manner as to impart the easy motion under a high speed on the former, and at a reduction of cost on the latter. He was induced to consider the velocipede as a medium to accomplish this result, and bruised himself up in a six hours experiment, in making himself master of one, from which he afterwards enjoyed many a pleasant hour's exercise on a smooth floor or surface. But he was soon satisfied that it was incompetent for any valuable service, for want of track and other motor than the muscle of man, before it could be made to enter into competition for any share of public favor. To model a suitable track for it was the first purpose, that steam might become the propelling power. By instituting a series of experiments in this direction, he became deeply interested, as he found his efforts were meeting with some success; and more particularly when his attention or experiments were upon a rail, of the prismoidal form. By a combination of wheels and axles, he found it a very simple and easy matter to lock the carriage to the prism in so perfect a manner that it would traverse many miles without the least danger of displacement, either on curves or straight lines. He was soon persuaded in his own mind that this was the proper form for a road bed for one rail. And his past two years' experience in running a short line in Alabama, leads him, unhesitatingly to announce here before this learned body, that the prismoid one rail railroad, as thus far developed, is equal to the accomplishing of the problem of cheap and rapid transportation, not only for the Grangers of the West and South, but to accomplish *elevated rapid transit by steam* through our crowded streets in populous cities; a task that *is now*, and has been for years past, puzzling our metropolis. He announces it for the following reasons: the prism utilizes all material used in its construction, in imparting strength both vertically and laterally; at the same time furnishing a cord of immense value in grading, bridging and trestling.

It presents a surface that is easily protected, and is best calculated to resist the action of the weather from wet to dry and freezing. It forbids traffic or travel of any kind, excepting for its own peculiar rolling stock, thereby saving much life and property that is now being destroyed daily and hourly on our present system of railroads, because of the inviting facilities offered to pedestrians, and good run-

ing ground for frightened animals, all of which tends to destroy life and property by the displacement of rolling stock. The prism in form, forbids accidents of this character. The great saving of life and property is a consideration of great moment to the traveling public as well as communities, through which lines pass. The wear and repair of said prism is far less, owing to the continuous cord that the prism makes, preventing low joints occurring from wet and freezing weather; obviates almost entirely the work on roads of ballasting and tamping under cross ties, and in the matter of grading, the same characteristic of the road that dispenses with so much ballast, offers increased facilities in crossing streams, short and deep ravines, or even long stretch of trestling; saving in one stretch, tens of thousands of dollars to the mile, that now becomes absolutely necessary under the present two rail system.

He states that, after nearly two years experimenting without arriving at the desired result, and soon after a mortifying failure in Steubenville, O., to get any car to round a curve on one rail successfully, he was riding through West Virginia, reflecting upon his experiment, when a remedy for the defect in the velocipede car fixed itself upon his mind.

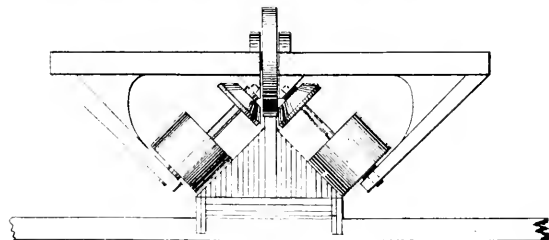
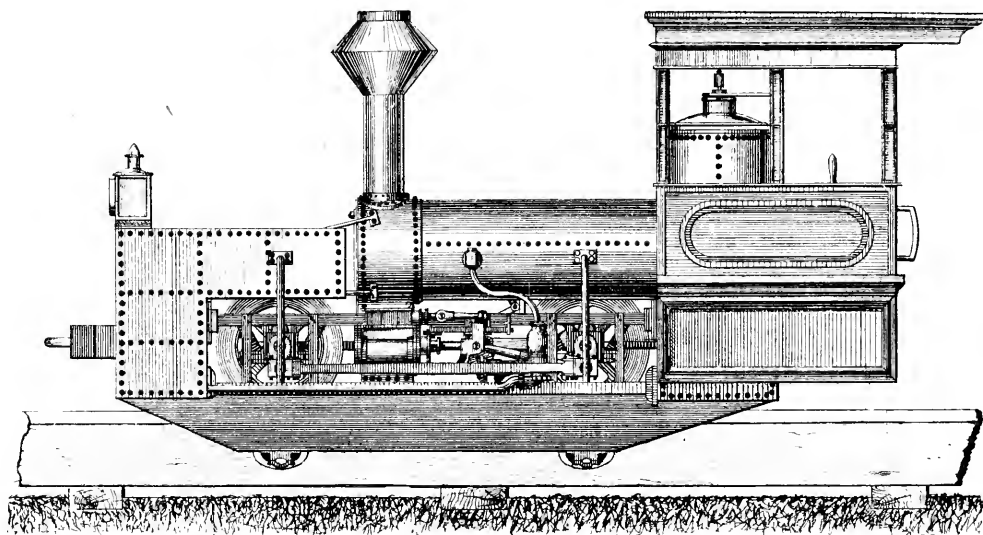
The reins were soon tightened up, and a vision came of a prismoidal rail, winding through the valleys and around the hills of that rugged, but—in minerals—wealthy country, waiting for cheaper transportation than the present system offers. It was then and there, within the short space of five minutes, based upon two years patient experimenting and study, that the true theory for rapid and cheap transportation made the impression upon his mind that he shall probably never forget, and which he has ever since given his best energies to bring to public notice. First, at Steubenville, O.; second, Cincinnati Industrial Exposition in 1871, and third, at Opelika, Ala., at an elevated street railroad. Last June, while operating this line of one mile in length, the attention of a street railway company in Atlanta, Ga. (that had been organized to construct a narrow gauge road) was directed to it, and they were invited to inspect this line, when it was unanimously adopted by the company, and admitted into the streets by a unanimous vote of the City Council, in lieu of the narrow gauge road originally intended. This adoption necessitated the construction of an engine (as motive power by steam was desired), and an open order from the President, M. G. Dobbins, without stint or limit as to time or price, has enabled him to bring forth the first engine, of

four tons weight, designed to move two coaches, each seating forty persons.

He felt prepared now to demonstrate more fully this new system, which he styled the "Prismoid One Rail Railroad," as being adapted to all classes of railroads, affording increased facilities for loading and unloading, carrying lines of track at great elevation, at a greatly reduced cost, and running curves with less friction and with absolute safety.

This system offers facilities to localities which cannot be reached by the present system, and will give rapid communication to the same, without the aid of foreign capital, enabling each community to own and control its own branch roads, its cost being less than one-half of the present system of same tonnage. A road of any carrying capacity can be constructed, the cost being the only limit, and branch roads, of but a few thousand dollars to the mile, can connect or switch its rolling stock on to a larger road of greater tonnage, and traverse it to the head of the market, without breaking bulk or transfer, as is necessary with different gauges now used. Were the Government disposed to respond to the wants of the Grangers to cheapen transportation to the sea board from the great grain fields of the West, this system could send out its branch lines to every village, from one Grand Main Prismoid Trunk Line, that could receive the smaller lines or prismoids, in trains bearing their thousands of tons. This system, he believed, would compete successfully with water in cheapness, and shorten distances as well as time consumed while in transit.

It gives great facilities and advantages in rapid travel. We usually expect, as the train moves out of a depot, in passing to New York or any other direction, that, as the speed of the train is increased, so is the lateral motion of the car, and if we attain fifty miles an hour we are under some apprehension of danger growing out of this lateral motion. Now the reverse of this might be said of the one rail system, for the higher the speed the less the liability to oscillate; so that we may infer there is no resistance to high speed growing out of lateral motion, where most, if not all, the resistance to a high speed usually comes from when two rails are used. These facts being true, he does not hesitate to say that it is practical to make the one hundred miles an hour—a feat, he believes, never yet accomplished—and that travel between New York and Philadelphia may yet be reduced in time to one hour and thirty minutes on a road with but one rail,





with less resistance than is now given to trains employing three hours to accomplish the distance.

It was believed and advocated in the earlier history of railroads, that eventually railroads would be built on a large scale with very broad gauge, mounted by stupendous coaches, giving a grandeur to travel, to compare with accommodations on steamboats; and many grave errors were committed in this direction, as is in evidence of the broad gauges that have changed gauge of rolling stock and track. There is a limit to width of gauge and a corresponding limit to palatial accommodation in railroad travel.

To prove the statements here made, he respectfully invited the attention of your body to a test that he was then making with the first constructed engine, in a trial trip of 500 miles; one-half of that distance on a curve whose radius is as short as the street railways turning corners, viz., $37\frac{1}{2}$ feet. Over one-half of the distance had already been run, and he expected to see the engine traverse the whole distance without accident or displacement, and with less wear and repair than the ordinary engines require in going the same distance.

His engineer has been honored with many of the prominent ladies and gentlemen of the State as passengers in the cab of the locomotive while making his circuitous journey, and without a single exception all are well pleased, showing conclusively that *prejudice* would not restrain the *public* from adopting even *one rail* when shown to be safe.

In conclusion, the petition is presented of the West End and Atlanta Street Railroad Company, which gives a description of the road. The road he proposed to build is to be built and constructed as follows: First, It shall not be lower than twelve feet, except at such points as the Street Committee shall give permission to build lower, and shall be built strong and substantial. It shall not interfere with any street which it may cross.

Second, There shall be a strong and very substantial prismoid rail of wood, not less than twenty inches or more than twenty-four in base. This prismoid track will be a strong and continuous cable, with sufficient strength to support twice the amount of weight that will ever be placed upon it. It will be constructed of strong timber, securely tied, and mounted at the apex with an iron rail.

Third, Upon this road they will run a train of cars; the cars to be substantial and very strong, and propelled by an engine placed

within a car, where it cannot ever be seen from without the car. There will be no steam thrown out from the side, no sparks from the smoke stack, nor any noise made that will frighten a horse. This train will run so smoothly upon the track that there will be no rattle or clatter—nothing to annoy business men or the most sensitive ear.

Fourth. These cars are kept securely upon this prismoid track by a combination of wheels, as follows :

(1st). There are two centre wheels on the iron rail, one at either end of the car. These centre wheels are maintained upon the track by revolving flanged wheels, one upon either side. These revolving flanges lock or key this centre wheel to the track, so that it makes it utterly impossible to throw the car off the track.

(2d). There will be a wheel upon the side of the prismoid with strong wrought iron bars to the side of the car ; these side wheels maintain the car in an upright position upon the track, and prevents any vibration of the car ; with this system of wheels the car is maintained in equilibrium upon the track and absolutely secure. The steps to the track to occupy only the width of the guttering, and to present no obstacle to the free exit of the water, and the steps to be closely closed.

A New Electric Light.—A novel and simple electrical light. has been suggested by Dr. Geissler, whose name is so intimately associated with some of the most beautiful experiments that can be performed by electricity—the plan being to make an electrical vacuum tube that may be illuminated without the employment either of the induction or the frictional machine. It consists of a tube an inch or more in diameter, filled with air as dry as can be obtained, and hermetically sealed after the introduction of a smaller exhausted tube. If this outer tube be rubbed with a piece of flannel, or any of the furs generally used for exciting the electrophorus, the inner tube will be illuminated with flashes of mellow light. The light is faint at first, but gradually becomes bright and softer. It is momentary in duration, but, if the tube be rapidly frictioned, the light is rendered apparently continuous upon the principle of the persistence of vision. If the operator have at his disposal a piece of vulcanite previously excited, he may, after educing signs of electrical excitement within the tube, entirely dispense with the use of flannel or fur. This will be found to minister very much to his personal comfort. He may continue the experiments, and with enhanced effect, by moving the sheet of vulcanite rapidly up and down at a slight distance from the tube. The phenomena here described are explained to be an effect of induction.

Chemistry, Physics, Technology, etc.

NOTE RELATING TO RUMFORD'S DETERMINATION OF THE MECHANICAL EQUIVALENT OF HEAT.

BY PROF. ROBERT H. THURSTON.*

In his "Sketch of Thermodynamics,"† Prof. Tait gives (p. 44, §78) a *resumé* of the history of the growth of that science, and presents the following as the order of its development :

First.—Newton's grand general statement of the laws of transference of mechanical energy from one body or system to another (1687).

Second.—Davy's proof that heat is a form of energy subject to these laws (1799).

Third.—Rumford's close approximation to a measure of the mechanical equivalent (1798).

Fourth.—Fourier's great work on one form of dissipation of energy (1812).

Fifth.—Carnot's fundamental principles, his cycles of operation, and his tests of a perfect engine (1824).

Sixth.—Thompson's introduction of an absolute thermodynamic scale of thermometry (1848).

Seventh.—Joule's exact determination of the mechanical equivalent of heat, and the general reception of the true theory in consequence of his experiments (1843-9).

Eighth.—The adaptation, by Clausius and Rankine, and subsequently, with greater generality and freedom from hypothesis, by Thompson, of mathematical investigation (partly based on Carnot's methods) to the true theory; the reëstablishment of the great second law by Clausius, with Joule's experimental verification of Thompson's general results (1849-51).

Ninth.—Thompson's theory of dissipation (1852).

Here, as elsewhere, the author of the above *resumé* states fairly the work done by Rumford, but here, as elsewhere, he places his services second in importance to those of Davy, as well as in their actual

† Sketch of Thermodynamics, by P. G. Tait, M. A., Edinburgh, 1868.

* Presented to the American Society of Civil Engineers, December 9th, 1873.

influence upon the growth of the science of Thermodynamics, and does not, apparently, consider them comparable to those of Joule.

In an earlier portion of the work (pages 7-9 §§ 13-15), the work of Rumford is correctly described, and a value of the mechanical equivalent is deduced and stated at 940 foot-pounds, the estimate being based on the assumption of 30,000 foot-pounds per minute as the true value of a horse-power. The experiment of Rumford consisted in the measurement of the heat developed by the power employed in boring cannon at the Arsenal, in Munich, and his paper describing the method and giving its results was published in the "Philosophical Transactions of the Royal Society of London" for the year 1793.

After showing that the heat evolved through the agency of friction could not have been derived from any surrounding objects, or by compression of the materials employed or acted upon, he says: "It appears to me to be extremely difficult, if not impossible, to form any distinct idea capable of being excited and communicated in the manner that heat was excited and communicated in these experiments except it be motion,"* add then goes on to urge a zealous and persistent investigation of the laws governing this motion. Estimating the quantity of heat evolved by a power which, as he states, could easily be exerted by one horse, he makes it equal to the "combustion of 9 wax candles, each $\frac{3}{4}$ of an inch in diameter."† This heat he also states as equivalent to the elevation of "26.58 pounds of ice-cold water" to the boiling point,‡ or 4784.4 thermal units, and the time occupied "one hundred and fifty minutes."

The "horse power" used by engineers as a unit of power measurement is 33,000 foot pounds per minute, but this figure, which was taken by Watt, originally, to represent the "average work of the strongest London draught-horses,"§ is much too high for application in estimation of animal power. It is well known among engineers that two-thirds of this figure is a more correct value. Rankine|| gives, for the average draught-horse, 25,920 foot pounds per minute, or 432 per second, and this value, correct as it probably is for Great Britain, is certainly too high for Bavaria. If the horse-power of Rumford be

* Abridged Phil. Trans., Vol. XVIII, p. 286.

† *Ibid*, p. 284.

‡ *Ibid*, p. 283.

§ Bourne.

Steam Engine and Prime Movers, p. 68.

taken at 25,000 foot-pounds per minute, a value far more likely to be correct than 30,000, as assumed in "Sketches of Thermodynamics," the mechanical equivalent, as deduced from Rumford's experiment, becomes 783·8, differing only 1·5 per cent. from the value now accepted as determined by Joule a half century later, which is nearer the probably correct value than the result of any other investigation, and is even far more accurate than many results obtained by Joule himself.

Could Rumford have eliminated loss due to evaporation, radiation and conduction, of which loss he was well aware, and to the influence of which he refers, it is very certain that he would have given us a more precise determination of this quantity than even that which is above deduced.

We may then claim for Rumford:

First.—That he was the first to prove the immateriality of heat, and to indicate that it is a form of energy, publishing his conclusions a year before Davy.

Second.—That he first, and nearly a half century before Joule, determined, with almost perfect accuracy, the mechanical equivalent of heat.

Third.—That he is entitled to the sole credit of the experimental discovery of the true nature of heat.

The "second" and "third" of the *resumé* quoted should, therefore, be transposed, even if the work of Sir Humphrey Davy should not be deemed simply the supplement of earlier labor and merely corroboratory.

BENJAMIN THOMPSON, of Concord, New Hampshire, commonly known as Count Rumford, should be accorded a nobler position and a higher distinction than he has yet been given by writers on Thermodynamics.

ON THE SANITARY CARE AND UTILIZATION OF REFUSE IN CITIES

BY DR. C. A. LEAS.

A paper read before the American Public Health Association, November 13th, 1873.

It has been said, and I think with much truth, that the disposition made of the offal from human habitations may with much propriety be received as an evidence or indication, not only of the cleanliness, decency, self-respect, and industry of a people, but of their moral and social condition, and when we see with what unconcern and indifference this grave and important subject of the disposal of refuse has been received and approached by legislative and executive bodies, during the past ages, we are filled with unbounded wonder and surprise, especially when we reflect that vigilant and astute sanitarians have, in all civilized countries, again and again, through many decades of the past, sounded the alarm from their watch-towers, and cried aloud from the house-tops, that these besoms of destruction, the epidemic and zymotic diseases, owe their existence in the main to defective sanitary regulations; to those active deteriorators of the public health, the heaps of festering and fermenting refuse matters, left unremoved and unutilized in and around the dwellings in our cities and towns. And not only do they thus speak forth in tones of thunder from the eternal world, but by their noxious effluvia demand removal, and are continually revealing and exclaiming, by this still small voice, that there are rich fertilizing qualities reposing within, which, if yielded up to the exhausted soils, to the demands of husbandry, will aid to promote abundance, cheapen food, and increase the demand for honest toil. Man, however, in sanitary affairs learns slowly the very important lesson that prevention is better than cure. He seems in these to have but little faith in the axiom that time ought to be grasped by the forelock, and hence he frequently slumbers and sleeps over volcanos of deadly miasm and noxious or pestilential effluvia, until, suddenly aroused by the bursting forth of blighting, withering, and devastating epidemics, which cost, besides the fearful loss of human life, sanitary reputation and commercial prestige, the expenditure of much treasure in crushing out that which might have been for a trifling outlay year by year altogether prevented. And therefore we cannot, in our mission as sanitarians, too strongly impress upon all people the important truth that in all matters relating to sanitary police and public hygiene, that what is deemed worthy to be

done ought to be promptly undertaken, and speedily and efficiently accomplished. Looking, therefore, at the question from all stand-points, we arrive at the conclusion that it is no economy to neglect or postpone the thorough cleansing of towns and cities until cholera or yellow fever has broken out, and it is no economy to discharge the contents of closets with kitchen offal into drains and sewers which debouche into tidal streams, causing thereby not only the loss of millions of dollars worth of rich manurial materials, but strewing, through the agency of the winds and tides upon the shores and docks, myriads of festering nuclei which in warm seasons exhale noxious gases to poison the atmosphere, and thus scatter disease and death among the people, to say nothing of the foul stench that are forced back by the winds through the sewers, drains, and traps into dwellings and sleeping-chambers, causing diseases of a low type, aggravating others of a mild character, and lessening the ordinary powers of vital resistance to other morbid and destructive agencies and influences, and, indeed, man's general capability for good. Nor is it compatible with common decency to thus pollute the waters of non-tidal streams from which others must draw a supply of water for drinking, cooking, and cleaning purposes.

The Refuse of Towns and Cities.—But it is not the subject of sanitary police, or public hygiene, in their very direct bearings that I am called upon at this time to contemplate; nor is it the baneful and destructive influence that unremoved excreta and other refuse matters have upon human life and health that I am expected to consider, but is the utilization of the refuse of towns and cities, or the best and most economical mode of treating and manipulating the refuse materials of large communities, so as to place them to good account, to render them sources of wealth and happiness instead of causes of misery, disease, and death. And yet this very subject has a somewhat intimate collateral connection with sanitary police and public hygiene, because, before we can utilize these refuse matters we must first get possession of them. We are, therefore, at the very threshold of our inquiry compelled to consider the best and most economical mode for their collection and transmission to safe and convenient localities, such as are out of the way and well suited for the process of manipulation.

To discuss the soundness of the wisdom which demands the restoration, as far as possible, to the soil, of such elements as were taken from it, in its efforts to furnish man with an abundant supply of food

and raiment, in order that this great storehouse of nature may be replenished with the materials wherewith to bring forth new evidences of its munificence and exhibit the infinite benevolence and loving kindness of God, would, it seems to me, be the height of folly. The economic and agricultural interests demand it, and our own common sense tells us that it is right, because in these offals and excrementitious matters, from the very nature of man's ingesta, that we find contained most valuable manurial and fertilizing qualities. And when we reflect upon the vast consumption of cereals and meats in various forms in the cities and towns of this and other countries, drawn from our fields and gardens, never again to return, then, and only then, do we begin to realize how solemn is the obligation to economize the wastes of our dwellings, stables, slaughter-houses, and streets, lanes, and alleys, and in a convenient and concentrated form, present them again to the soil from whence they came, and not only so, but at the same time to enrich the people's treasury?

What is Refuse?—With a view to a clearer comprehension of the nature or character of the substances refused by man, that collect about his dwelling-places, and require removal from considerations of health and convenience, we will say that they consist of all refuse and offal from houses, such as ordure and excreta; the vegetable and animal garbage from kitchens, including coal and other ashes; the sweepings of houses and yards; old and worn-out pans, kettles, and boots and shoes; the scrapings and sweepings of streets, lanes, alleys, and courts; dead animals; the unutilized materials from factories and workshops; and last, but not least, the offal and garbage from slaughtering establishments. Happily, however, for our public treasuries, that some of the substances here enumerated do not fall for their removal upon the public authorities, hence I have concluded to embrace within the scope of these remarks the utilization of only such of the refuse matters as come under the immediate and daily observation of public sanitary authorities, and as fall into their possession, either direct or indirect, for removal and disposal. And although the garbage and offal from slaughter houses as a general thing do not come under this head, and are in the main removed soon or late by the owners of such establishments to the country, and their most valuable fertilizing properties in some way or other utilized for agricultural, horticultural, or other purposes, yet I will here remark that nevertheless the efforts of many gentlemen engaged in the butchering and slaughtering of animals to preserve their premises in a cleanly and

sweet condition, a greater outrage can hardly be perpetrated upon a people than the toleration within towns and cities of such establishments. They, together with their kindred, the melting and boiling houses, soap and glue factories, and bone-grinding and crushing establishments, ought to be banished into suburban places, and the atmosphere of crowded localities saved from the contaminating influences which result from the retained filth and offal for hours, and sometimes days, in closets and dung pens, festering and fermenting out in warm weather pestiferous gases, which act like slow but sure poison upon the human organism; and, besides, in suburban localities or open country the flesh of slaughtered animals can be better prepared for the markets; the atmosphere being purer, the meats are less liable to take on speedy putrefactive action. The animals themselves, from the same cause, are in a more healthy condition, and, besides, the people saved the further danger, annoyance, and damage to health and traffic, resulting from the driving of sheep, oxen, and swine through crowded thoroughfares. But it ought not to be forgotten that these open country localities for abattoirs or slaughtering purposes should be located upon streams, the waters of which are not afterwards to be used for drinking, culinary or cleansing purposes.

Modes of Scavenging Towns and Cities.—Various and dissimilar have been and are the modes of scavenging large towns and cities, and collecting for removal the ordinary offal and garbage from the streets and dwellings, both in this and other countries. In parts of the West Indies the dead animals and some other portions of refuse matter are referred to the buzzards for removal, and it may be said that as scavengers in this relation they are prompt and efficient, doing their work quick and well. In some European localities the owners of property are required to cleanse the public thoroughfares in front of their respective premises, and to remove the house offal, which generally accumulates in the courtyards and other places for days and weeks, until the amount proves equal to one or more wagon-loads. Such, for example, was the case in the imperial City of St. Petersburg, until the inauguration of an American scavenging system; hence it may not be wondered at that cholera had previously prevailed in that city more or less the whole year round. In other places the contiguous farmers and gardeners, with their long covered wagons and the help of their women, collect the garbage and street manure, and apply them to their lands, the removal costing the authorities nothing. Again, in others, the scavenging service is, in

whole or in part, confided to contractors, who in the main regard more attending to their own pockets than the public health and convenience. The municipal authorities of some towns and cities employ the scavenging forces, but lack fixed regulations, especially in the removal of the garbage from dwellings, the carts visiting at any and all hours of the day, thus causing the exposure of masses of filth and rubbish upon the sidewalks, in the gutters, and in and about dwellings for hours, to the great detriment of health, sight, and smell. Others cause the collection of kitchen offal and house ashes separately by two sets of carts, with the view to the utilization of the ashes for the filling of sunken lots, and the vegetable and animal offal for the feeding of swine, while others collect all together, making the same cart one heterogeneous mass of vegetable, animal, and mineral matter, and either depositing the same upon open and sunken lots, where it acts as a poison to the atmosphere of whole neighborhoods, or, to avoid this, it is covered with a layer of good earth, which makes a fair show outwardly, and smothers up, and renders less rapid the process of putrefaction. Nevertheless, it is true that good earth is a most valuable deodorant; yet it may also be regarded as certain that, if this deposited mass should be disturbed or uncovered in the process of cellar digging short of three or four years, the gases sent through the houses built upon such foundations will be productive of fearful disease and general bad health.

The Proper Mode of Collecting Garbage.—To secure and maintain the confidence of the people in any effort at refuse utilization, the mode and manner of its collection and removal must combine both economy and efficiency. You will, therefore, be pleased to pardon a little digression, with the view that I may, in a succinct form, lay before you my views in this relation. The garbage or kitchen offal, including coal and other ashes, yard and cellar sweepings, ought to be collected daily in the warm seasons, and at least three times per week during the other portions of the year, and with the view to constant cleanliness within doors, and a proper utilization of refuse matters, housekeepers, and all others interested, ought to be required to separate the ashes and earthy substances from the vegetable and animal offal, and in this form to present them with absolute regularity to the garbage collector, when he shall appear before the premises, and further to remove from public view the empty vessels immediately after the departure of the cart, which, together with the horses, ought to be large and substantial, and the former pro-

vided with a movable division board, so arranged as to shift little by little, fore and aft, and with an upright bolt, so that by the drawing of which the board will fly open from below upward when the cart is tilted. This partition will furnish two compartments, one for the ashes and the other for the animal and vegetable refuse, and can be shifted as the seasons advance, one upon the other, or in proportion as the ashes predominate over the vegetable and animal materials collected. Housekeepers and others ought to have sufficient warning, through the frequent sounding of a horn, aided by the ringing of team bells upon the hames of the horse, of the near approach of the cart, so that then, and not before, they may bring out their garbage; and they ought to be strictly enjoined not to expose their refuse matters upon the streets and sidewalks in advance of the time for the visit of the cart; but the officer in charge of the service ought to see to it, through the proper districting of the town or city into garbage beats, and the maintenance of proper order and discipline; that the carts appear, as to time, with almost the same degree of regularity as characterizes the arrival and departure of railroad trains. Unfaithfulness, loitering, or drunkenness on the part of employes ought to be promptly punished, as the people's health, lives, and convenience ought not to be compromised or placed in jeopardy through political or other influences. The garbage and refuse thus collected ought to be removed, either by water, rail, or carts into the country, and as much as possible out of the way of habitations and into grounds inclosed and prepared for their reception, the ashes placed under sheds and sifted, and held in stores as an absorbent and deodorant, and the vegetable and animal portions dumped into compost pits.

How Garbage is Collected in Baltimore.—I had the honor of inaugurating in the City of Baltimore, nearly twenty years ago, a system of collecting garbage, and it has maintained its place and popularity for nearly two decades, amid all the changes of men, measures, and parties, and when honestly, energetically and conscientiously executed, has given uniform pleasure and satisfaction to the people. And not only so, but the present Emperor of Russia, some years ago, ordered one like it to be put in execution in the City of St. Petersburg, after an Imperial Commission had reported that in all the European cities visited for the purpose of investigation, none was found equal to it as a scavenging system. The house-wives of Baltimore have been so trained and schooled, through the kindness, gentleness, and firmness of the Sanitary Department, added to their

own good practical judgment and dispositions of cleanliness, to regard the garbage-cart, not only as a necessity, but its regularity even to hours as of such grave importance as to call forth complaints when failure occur, and all such complaints ought not only to be encouraged, but carefully and promptly inquired into. The improvements or additions to this system—namely, the separation by families of the garbage from the ashes, the movable division-board in the carts, and the hauling by cart nearly two miles into the country—were adopted at my suggestion, and inaugurated nearly one year ago, with the view to the utilization of all this refuse, together with the night-soil or contents of privies, which cess-pool matter was at the same time ordered to be removed by the independent nightmen, in their carts, to the city dumping-grounds, which last regulation gave rise to an advance in the cost to property-owners of cleaning privy-vaults, and which, in its turn, together with other wise sanitary reasons, created the necessity of inaugurating the system of cleaning these places by the pneumatic suction plan, which, in case the machinery can be so perfected as to remove by suction the ordinary solid excrementitious matter, I consider to be a decided improvement, and ought by all means to form a part of the sanitary system of all large towns and cities. And again, besides the advantages in a sanitary or hygienic point, it ought to give rise to a reduction in the cost of cleaning closets nearly if not quite one-half, from the fact that the worst can and is done by day, thus giving full opportunity for double the working hours and larger loads. And, furthermore, property-owners and others interested, can see or determine with exactness the amount of service given by the night-men, and thus be enabled to audit the bills and save unrighteous drafts upon their purses and patience.

The Model Garbage Carts.—The movable division board in the cart saves the expense of duplicated carts in the collection of garbage—an expense the politicians feared very much. Then, again, it was supposed that to require families to provide a second garbage vessel would give rise to such an avalanche of indignation that no political party could stand against it; but, on the contrary, it was found that on the day fixed for the commencement of the garbage-separation system—which was fully made known to every family, by means of advertising and handbills circulated into every house, through the agency of the police—every family in the City of Baltimore—a city of over fifty thousand houses—had their garbage separated, and ready at the appointed hour for the garbage collector, save very few, and

the neglect of these few was found, upon investigation, to be the result of ignorance rather than unwillingness; and up to this day I am not aware of a single fine having been imposed, as provided in the law. And indeed the whole thing has become popular with the people, and thus this objection, a mere *ignis fatuus* in the minds of those that scare at shadows, has vanished, and when these fearful ones expected this overwhelming ruin they found only praise and eulogiums. At first was feared that the weight in the cart would be unequal; that either the load would be too heavy in front, and thus crush down the horse, or in the rear, and thus tilt the cart backward and hang the animal; but this difficulty soon also vanished when I showed the garbage men how to load in order to preserve the centre of gravity through the axletree.

Disposal of Manure.—Night-soil possesses, next to bullock's blood, the most valuable manurial properties, being well adapted to the growth of all kinds of crops, but especially those requiring a large amount of nitrogen or ammonia. I therefore ask, then, if these things be true, is it wisdom, is it true economy to allow these sources of wealth to flow through our drains and sewers into the bays and rivers, to be forever lost, or if returned in any form, to be in the shape of epidemic, pestilential, and low forms of disease, and the expenditure of millions to dredge out our docks, rivers, and ship channels, saying nothing of the damage done to the fresh water streams through their pollution by this system of drainage? Sewers and drains were originally designed to convey away the surface drainage, and this system of sending through them all refuse matters, is a serious departure from this original intention, and which ought not to be continued. I know there are difficulties surrounding this whole matter of closet vaults; the contamination of the atmosphere which they cause, especially when being cleaned by the miserable cart and bucket man and the partial contamination or damage to contiguous wells and spring. But then we must not forget that there are very few large communities dependent for a supply of water upon the resources here referred to, nor yet upon this old rotten borough system of cleansing by cart and bucket. Therefore, in view of these things, the new mode of disposing of kitchen sewage and human excreta by drains and sewers renders, in my judgment, the last end worse than the first. Until, therefore, the people can be educated up to a well-regulated system of earth or ash closets, which ought to be as soon as possible, let us, at least for the present, stand by the cess-pool plan of accumulation,

and a perfected pneumatic suction system of cleansing, and utilize, in compliance with the plain dictates of nature, for the benefit of agriculture and the taxpayers, this large mass of refuse material.

Location and Construction of Refuse Depots.—But now the question comes up, how are these waste matters to be utilized? The answer I will endeavor to give. And as was before stated, economy should always travel side by side with efficiency, therefore it is recommended to all towns and cities having navigable rivers running through or convenient to them, and not liable to ice-blockade, to use these to convey away, in suitable boats, tanks, and hoppers, these refuse matters to proper dumping grounds. If these, however, do not exist, or if existing, cannot be availed of, then the next best agents for transportation are railroads, and lastly, if these are not convenient or will not afford the required facilities, then there remains nothing but the horse and cart, which is the case in Baltimore, where the garbage and excreta are, by this means, transported about one mile and a half into the country. In any effort, however, to successfully utilize refuse, a market for the large amount of compost must not be overlooked in the selecting of depots for dumping purposes. This whole field must be well canvassed in its agricultural and horticultural bearings and relations, and confidence well founded that the outlet is well secured, and the demand will be quite equal to the supply. To this end and for this purpose let the section of country which may be induced under favorable circumstances to draw a supply of fertilizers from the depots, be as large as possible, and with the further view that these fertilizing boons from the towns and cities may penetrate to and enrich as far as possible those whose toil and labor contribute to the wants and necessities of the urban populations. But even if circumstances should demand the removal by horse and cart, yet the necessity will still exist for locating the dumping places so near to either railroads or navigable streams so that collateral tracks may be constructed without much cost either of construction or after working. The poudrette can be readily removed to the city in sacks or barrels and stored in warehouses for sale, but the composts cannot be so treated—those, from their crude nature, must be shipped or hauled direct to the farmers and gardeners. The ground, in quantity, should be sufficient for all present and future purposes, and having a light backward declivity, it should be inclosed by a high board fence, and containing, besides long sheds for the reception for coal and other other ashes, stowage-room for sifted ash, poudrette, old coal, old bones

and rags, boots and shoes, and implements; also, two rows of night-soil tanks, capable of holding each at least twenty three thousand gallons; large drying floors; below the tanks a number of compost pits; a small house for the protection of the superintendent by day and the watchman by night; a pump to furnish water for man and beast, and, if necessary, feeding troughs for horses, and lastly, the required supply of forks, shovels, sieves, wheelbarrows, and scrapers; two or three horses and carts will also be wanted to haul materials from one locality to another.

Mode of Handling Refuse Matters in the Dumps.—The above is a faithful description of the mode of constructing and manner of furnishing the Baltimore dumps, and I have given them in detail because I advised their construction and equipment, and are, therefore, whether good or bad, the embodiment of my own ideas in this relation, and I will now further, from the same cause and for the same reason, describe the manner of handling and treating the refuse matter after reception within these depots. The ashes are dumped under the sheds, and then separated by the process of sifting from the coal, bones, rags, and other matters, and the vegetable and animal offal from houses into the compost pits for after treatment. The night-soil is dumped or pumped from the wagon-tanks into the first or upper row of tanks, after passing through a grating fixed in front thereof to separate and detain from the ordure all stones, bricks, sticks, hoop-skirts, and old clothes. As the contents of privy-vaults contain, as a general thing, a larger amount of urinous than solid matter, the former rises to the surface, and when the upper tank is full, this supernatant liquor is decanted through long troughs into the compost pits containing the vegetable and animal offal before referred to, and a percentage of sifted coal-ash added to act as an absorbent and deodorant. The filling from the carts and the decanting is carried forward until the first tank is full of solid, or rather semi-solid matter. This mass or residuum is then allowed to pass through a flood-gate into the second row of tanks, where sifted coal-ash is added, which acts immediately as an absorbent and deodorant. Indeed, practical experience and observation have fully demonstrated that two thousand pounds of sifted coal-ash will, in fifteen minutes, completely deodorize six hundred gallons of manure. The amount of sifted ash now ordered to be added to the ordure for the making of poudrette is two parts of the latter to one of the former, or one of ash to two of night-soil, though, for the purposes of greater strength and concen-

tration for transportation purposes, one part of sifted coal-ash may be added to three or four parts of night-soil, which makes a beautiful dry poudrette, and will, I doubt not, prove quite equal in its fertilizing qualities to the best guano, and far superior to many of the fertilizing agents now sold in the markets for from \$40 to \$60 the ton. The mixture thus made in the second row of tanks is, after deodorization, thrown upon the drying floor about three inches deep, which, if the weather be favorable, will dry in a few hours. The mass is then removed and thrown out upon a heap; a process of heating takes place, in which the great and small lumps or clods that were formed upon the drying-floor fall or crumble into powder. The whole is then run through a sieve or screen, and is the fine or double-refined poudrette—according to the capacity of the sieve—which is sold by the Corporation of Baltimore for from \$15 to \$20 the ton, and its popularity is I am informed, being well established with the farmers and gardeners who have used it upon their lands. This poudrette, thus made from no other materials than the raw contents of privies and coal-ash, is a fine, dry, inodorous powder, which might, with great propriety, be exhibited in a parlor filled with ladies and gentlemen of the most refined character. Composed of three parts of night-manure to one of coal ash, and upon examination it will be seen how perfectly the ammonia is fixed, and how thorough and complete has been to the deodorization. The compost made from the kitchen offal, a portion of sifted ash and the supernatant liquor from the manure tanks, is sold by the cart load of forty cubic feet, or thirty bushels, at seventy-five cents, but it is an exceedingly rich manure, as can well be understood from its miscellaneous or heterogeneous character, being composed of rich vegetable and animal matters. This manure is the most fertile of all the fertilizing agents, and has, doubtless, a far greater monied value, and which will probably be yet realized, when the authorities shall have connected the dumps with the railroads that pass near them, so that the far distant fields and gardens can be allowed, upon reasonable conditions, to partake of or share in this ocean of marrow and fatness. The old rags and bones are separated as before stated, from the ashes and also from the kitchen offal and night-soil and sold, considerable revenue being derived therefrom; and the old boots and shoes can, I understand, be reduced to powder by the process of burning and sold for the case hardening of iron, the old coal either sold for reburning or for the making of roads; so it will be seen that the utilization of everything collected has been

provided for, save the old pans and kettles, and I do not despair even of these. It may be, that ere long, some branch of business will require them for some useful purpose.

The Utilization of Scrapings and Ashes.—It has been stated that coal-ashes possess no agricultural or fertilizing value whatever, but such is evidently not the case, for besides the trace of wood-ash that they contain, which yield alkaline salts, they have in themselves properties, chemical and mechanical, which the soil requires, and I have seen, in our Baltimore dumping grounds, splendid tomatoes, pumpkins, citrons and tobacco growing from a bed of pure coal-ash and cinders. A sample of the Baltimore City poudrette was submitted to Prof. Leibig for analysis, composed of one part of ash to one of night-soil, and it was declared to have a value of \$15 per ton of 2000 pounds, when viewed in the light of the report of the United States Commission of Agriculture at Washington, and as compared with the double-refined poudrette of the Lodi Manufacturing Company of New York, an article which, it is said, finds a ready sale at \$25 per ton. If, therefore, this Baltimore poudrette of one to one has such a value, what will be the value of a poudrette made of from say four of human ordure to one of ash? The answer will probably prove it to be quite equal to the best guanos. The analysis of Prof. Leibig exhibits the constituents to be ammonia, phosphoric acid, bone-phosphate of lime, alkaline salts, and lime, all of which are important and even necessary in the growth of crops.

I have made no special reference to the utilization of the scrapings and sweepings of streets, because these generally find a ready sale. They, however can I doubt, not be made of greater value by admixture with the compost matters, as the supernatant liquor from the night-soil tanks is quite sufficient for complete saturation, even after these shall be added.

I have also not referred to the plan of utilization by irrigation as practiced in some parts of England and Scotland, through the instrumentality of ditches, pipes and jets. This plan comprehends the utilization in the form of liquid manure or sewer water, in which the kitchen offal and other matters are held in solution, and suspension. This mode of applying refuse matters to useful purposes admits of the discharge of refuse matters into drains and sewers for collection at the mouths of the latter, but I apprehend it could not be availed of to any extent in this country. I, therefore, even if it were compatible with a well regulated sanitary system, dismiss it as being impracticable, at this time at least.

Franklin Institute.

HALL OF THE INSTITUTE, February 18th, 1874.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last stated meeting and of the special meeting, held Friday, January 30th, were read and approved.

Some doubt having been thrown upon the correctness of the clause of the minutes of the last stated meeting referring to a proposed amendment of Mr. J. W. Nystrom, it was, upon motion of that gentleman, resolved that the same be considered to be a resolution passed. Carried.

The passage in question would therefore read:—

“Resolved, That the Institute shall hold a conversation meeting on the second Friday of each month, from 8 to 10 P. M., except in the months of July and August.

“That the members shall be at liberty to converse freely in the hall of the Institute during the conversation meeting; and that no lecture or other meeting shall be held at the Institute during the conversation meeting.”

The Actuary presented the minutes of the Board of Managers, and reported that at their stated meeting held February 11th, 1874, donations to the Library had been received from the following sources, viz.:

Patentee's Manual, showing the manner of Securing Inventions by Letters Patent in Canada and Foreign Countries. From Charles Legge & Co., Montreal.

Comptes Rendus hebdomadaires des Sciences de l'Academie des Sciences, Nos. 2 to 20, 1873. From the Academy, Paris.

Bulletin de la Société d'encouragement pour l'Industrie Nationale, for August, September, October and November, 1873. From the Society, Paris.

Annales de Chimie et de Physique, for August, September, October and November, 1873. From the Editor, Paris.

Proceedings of the Philosophical Society of Glasgow, 1872—73. From the Society.

Proceedings of the American Iron and Steel Association at Philadelphia, November 20th, 1873. From the Association.

Bulletin of the National Association of Wool Manufacturers, October—December, 1873. From the Association.

The Actuary reported also the fact that the Board had appointed Messrs. Chas. Bullock and Bloomfield H. Moore, Curators ; and D. S. Holman, Actuary for the current year. He likewise reported the following resolution :—

“*Resolved*, That the Board of Managers recommend to the Institute the passage of a resolution instructing the President to express by letter to Mr. George W. Childs and to Mr. W. V. McKean, of the *Public Ledger*, the thanks of the Institute for the carefully prepared editorial in its issue of February 3d, which was so earnest in its advocacy of the utility of the Franklin Institute.”

Mr. Nystrom moved that the recommendation of the Board, as read, be adopted.

Mr. Orr moved to amend by including in the vote the *North American* newspaper, and supported his request by reading from a copy of the paper in question, of that day, a very appreciative and encouraging editorial. The amendment was accepted, and the amended motion was carried.

The President next announced the following standing committees for the current year :—

Library.

Chas. Bullock,	William H. Wahl,
Samuel Sartain,	C. A. Evans,
William P. Tatham,	B. H. Moore,
Jos. W. Wilson,	J. W. Nystrom,
Dr. Geo. F. Barker,	Dr. Isaac Norris, Jr.

Minerals.

F. A. Genth,	John C. Trautwine,
Theo. D. Rand,	Edward F. Moody,
Samuel B. Howell,	R. E. Griffith,
C. S. Bement,	Jos. M. Wilson,
William H. Wahl,	F. H. Reichard.

Meteorology.

Pliny E. Chase,	Thos. S. Speakman,
Hector Orr,	James A. Kirkpatrick,
Dr. Isaac Norris, Jr.,	David Brooks,
Robt. E. Rogers,	Alex. Purves,
John Wise,	William H. Wahl.

Models.

Wm. B. Bement,	Edward Smith,
F. B. Miles,	D. S. Holman,
Edward Brown,	J. B. Knight,
Theodore Bergner,	C. Chabot,
John Gœhring,	Wm. B. LeVan.

Arts and Manufactures.

A. B. Bary,	Raphael Estrada,
Geo. V. Cresson,	H. B. Bartol,
Hector Orr,	J. Sellers Bancroft,
Coleman Sellers, Jr.,	John Richards,
Wm. P. Tatham,	Alfred Mellor.

Meetings.

Geo. F. Barker	Chas. S. Close,
B. H. Moore,	Pliny E. Chase,
Samuel Sartain,	Wm. P. Tatham,
J. E. Mitchell,	J. Sellers Bancroft,
Washington Jones,	Henry Cartwright.

The Secretary next read his monthly report on Novelties in Science and the Mechanic Arts. At the conclusion of the same, Mr. Close moved that the document presented by the Secretary, concerning the amended Congressional bill relative to the carrying of steam pressure by steam vessels used for towing and carrying freights on Western rivers, be referred to the Committee on Science and the Arts, with the request that they report thereon to the Institute. Carried.

Mr. Hector Orr then presented the following:

“Resolved, That the Institute repeats its resolution of last year, recommending a general and thorough geological survey of the State of Pennsylvania, and respectfully urges the providing for the same by our Legislature now in session.” Carried.

Mr J. Morgan Eldridge next called the attention of the Institute to the propriety of holding an Exhibition of Arts and Manufactures during this, her semi-centennial year, and stated that it was highly probable that a suitable building, namely, the freight depot of the Pennsylvania Railroad, would be vacant at the desired season, and might be placed at the disposition of the Institute for that purpose, if the needful representations are made. Mr. Eldridge then moved that the subject be referred to the Committee on Exhibitions, with the request that they give the matter their early attention.

Mr. Mitchell strongly supported the remarks of Mr. Eldridge, and seconded his motion, which was carried.

Mr. J. W. Nystrom moved to refer the subject of the Confusion of Dynamical Terms to the Committee on Science and the Arts. Carried.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*

JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE STATE OF PENNSYLVANIA.
FOR THE
PROMOTION OF THE MECHANIC ARTS.

VOL. LXVII.]

APRIL, 1874.

No. 4.

EDITORIAL.

ITEMS AND NOVELTIES.

Shaw's Relief Block for Rolling Mills.—At the last meeting of the Institute, Mr. Thomas Shaw, of Philadelphia, presented the improved mechanism, of which he gave the following description :

The invention, which is here-with illustrated, is designed to prevent the breaking of housings, rolls, and other gearing pertaining to rolling mills, and to afford instant relief when the engine is overloaded. In order to fulfil the object mentioned, the demands made upon the invention are peculiar, for it will be observed that the power of a rolling mill is a thing not to be trifled with, that no elasticity is permissible, that the adjustment should be under perfect control, and not liable to disorder when adjusted, and that the parts should be so arranged that the operator will be enabled

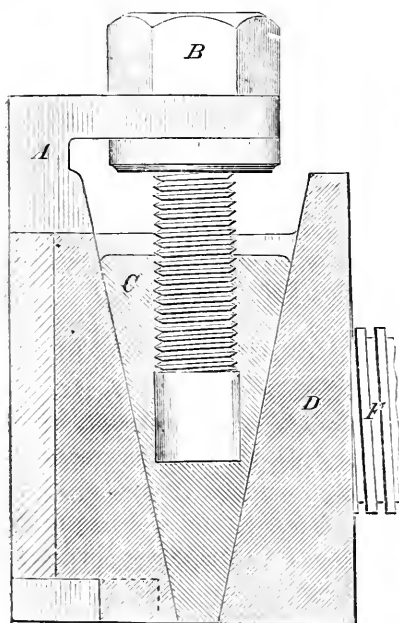


Fig. 1.

to release a load of 500 to 1,000 tons with an ordinary bar wrench, when emergency requires.

All of the foregoing points are met in Mr. Shaw's Relief Block, which consists of an obtuse wedge *C* (Fig. 1.), supported on the top of its bed-plate *A*, of corresponding angle. The said bed-plate terminates in a flange on its outer end for the reception of the collars of screw *B*, which screw is tapped in to base of wedge *C*, and controls the movements of the same. The wedge *C* is covered by a top-plate *D*, having side wings, as shown in (Fig 2), reaching down to plate *A*, to prevent any lateral movement of the three separate parts. The angles of wedge *C* are made sufficiently obtuse to cause the

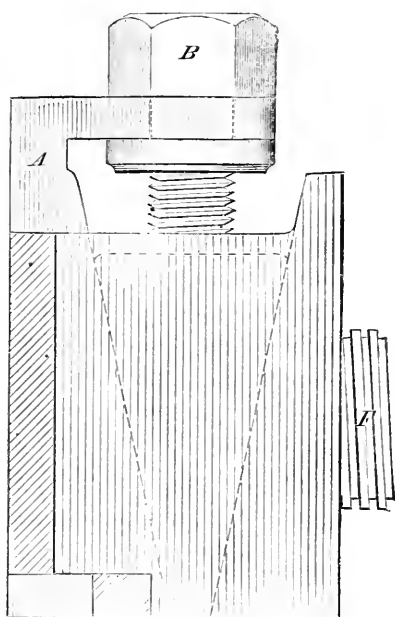


Fig. 2.

It will be observed how easily this invention accomplishes its task of relieving the screw, rolls, and housings of the severe strain, when metal is caught and locked between the rolls, by using the force of the strain between the journals to eject an obtuse wedge at the will of the operator. The Relief Block is perfectly solid and free from all elasticity, (unlike hydraulic presses tried for the same purpose), and will always maintain the height at which they are set, and can be used for slight adjustments of the rolls when required; and by introducing them, it will no longer be necessary for rolling mill owners.

wedge to be squeezed outward whenever pressure is applied, but the angle should be so acute as not to give any great force to this outward tendency. This angle will vary with the material employed in its construction; with steel, three inches to the foot being a sufficient angle for each side of wedge *C*. Whenever it is desired to withdraw the wedge, it is only necessary to apply a spanner wrench to the head of screw *B*, which can be revolved under all loads. This Relief Block is placed in an ordinary housing *G* (Fig. 3), on top of the journals of rolls *I* and *H*, and the housing screw *F*, pressed upon the top of said Relief Block..

to place engines of 50 to 70 per cent. of excess of power, to crowd through the rolls whatever may be placed between them without regard to the strength of rolls and housings, to the imminent risk of breaking and damaging expensive machinery.

All machinery liable to excessive strains should have a limit of safety before its maximum strength is reached. In rolling mills, this engine is the best safety-valve for over-strain, which should be so proportioned with steam, as to stop the engine before breaking the machinery.

There need be no fear of the engine slacking up under ordinary work, for the damaging strain is from 50 to 100 per cent. in excess of ordinary loads. Whenever the engine slacks speed from excessive

strain, liable to break the machinery, instant relief can be afforded by the Relief Block here described.

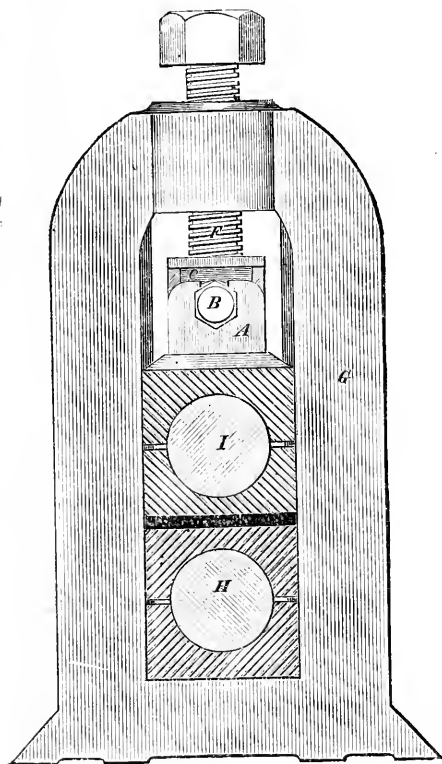


Fig. 3.

Coal-cutting Machinery.*—An exhaustive treatment of the subject of coal-cutting by machinery, and its probable influence on the future of coal mining industry, was lately had before the Cleveland Institute of Engineers, Middlesbrough, England. The conclusions derived from this discussion are stated to have been taken from the best results of the best machines yet invented. This distinction seems to have been accorded without dispute to the so-called Gartscherrie coal-cutter of the Messrs. Baird, which has been in operation constantly at several large collieries ever since its first introduction, some six or seven years ago. The advantages claimed for this machine are:—1, a diminished cost of production; 2, an improved ven-

* American Exchange and Review, April, 1874.

tilation ; 3, a reduction of waste ; and 4, a relief to the miner from the hardest part of his toil.

In consideration of the extent to which the conditions just enumerated are fulfilled by coal-cutting machinery, the following data were brought out, concerning the working of the machine here mentioned. The data are, however, necessarily imperfect, from the fact that the application of coal-cutting machinery has not yet been tried on a scale sufficiently extensive and complete to give a definite idea of the minimum cost of production. The following tabulation, based on the result of a year's working, gives the cost and the number of men required to remove 120 yards of coal (equal to 130 tons) holed by the Gartsherrie coal-cutter :—

<i>No. of Men.</i>	Cost.	
	<i>s.</i>	<i>d.</i>
24 Hewers (per ton),	1	5
8 Deputies “	0	5
6 Putters “	0	2½
6 Men at cutters,	0	3¾
3 Brake and foremen,	0	1¾
2 Men repairing cutter chain,	0	1¼
<hr/>	<hr/>	<hr/>
49	2	7¼

To get the same quantity of coal from the same colliery by hand-labor would require :—

<i>No. of Men.</i>	Cost.	
	<i>s.</i>	<i>d.</i>
67 Hewers (per ton),	3	3
6 Putters “	0	2½
6 Deputies “	0	3¾
<hr/>	<hr/>	<hr/>
79	3	9¼

Showing a difference in favor of the coal-cutter of 1*s.* 2*d.* per ton.

At another colliery, the cost of doing the same work is estimated at 3*s.* 1¾*d.* per ton, an increase which is attributed to the comparative thinness of the seam (two feet six inches.) Taking, however, the best performance of the coal-cutter as a basis of calculation, and extending its economical showing over the total production of the United Kingdom, the fact is demonstrated that if coal-cutting machinery were universally adopted, there would be an economy of at least £6,000,000 effected in raising the 120,000,000 tons of coal now annually produced in the United Kingdom.

With regard to the subject of the extent to which the introduction of coal-cutting machinery will reduce the number of colliery operatives, which is an important phase of the question, it is estimated that the force now employed in the aforesaid production (418,088) could be reduced to at least 200,000. The substitution of machine for hand labor will, in every probability, be so slow as to make no serious disturbance in the employment of colliers, while the increase of production will probably be so unprecedently large within the next decade as to require the labor of all at present employed.

With respect to the reduction of waste, it is declared that the total loss from this cause, with the Gartsherrie machine, is about 5 per cent., or 15 per cent. less than the average proportion of waste by hand hewing,

The relief of the miner from the hardest portion of his toil is advanced as a recommendation, which, from a humanitarian standpoint, should lead to the universal adoption of coal cutting machinery. It is argued, and with truth, that workmen frequently throw needless and vexatious difficulties in the way of employers who seek to introduce improved processes and appliances. In this case, however, any objection from the workmen would seem to be unreasonable and shortsighted. The hardest work devolving on the miner, with the machine cutter, is mere child's play compared with the hand hewing.

In how far the foregoing arguments may apply to American coal-mining industry, it is not easy to say; inasmuch as the condition of things here is very different. We know of but one case where coal-cutting machinery has been employed, namely in the block-coal fields of Indiana, already referred to in a former issue of the *Journal*, and in that, the verdict which it has commanded is a favorable one. It has been found, however, that the economy of such machines is most evident where the seams worked are of moderate thickness; and their introduction into our anthracite mines, where the seams are often of enormous dimensions, is a very improbable contingency, for the present at least. In England, however, the subject has assumed important proportions, as may be drawn not only from the extent to which such machinery has been introduced, but from the following closing remarks of an eminent speaker before the Cleveland Institute of Engineers:

“England's future prosperity must, to a large extent, depend upon her mineral resources, and these mineral resources will be largely affected by coal cutting machinery. The experience of the past two

years has amply proved that any restriction of, or interference with our coal supply is sufficient to disorganize all the springs of industry, and entail more or less of hardship, mischief and inconvenience on every class of the community. I do not think, then, that I have at all exaggerated the importance of coal-cutting machinery in reference to the coal trade; nor shall I greatly err in predicting that in the not far distant future it will become to the miners and mine owners the question of questions, and receive much more consideration than it has ever done in the past."—W. H. W.

Baker's Rotary Blower.—At the last meeting of the Institute, there was presented for exhibition and described, the apparatus above-named, of which we herewith append external and sectional views :

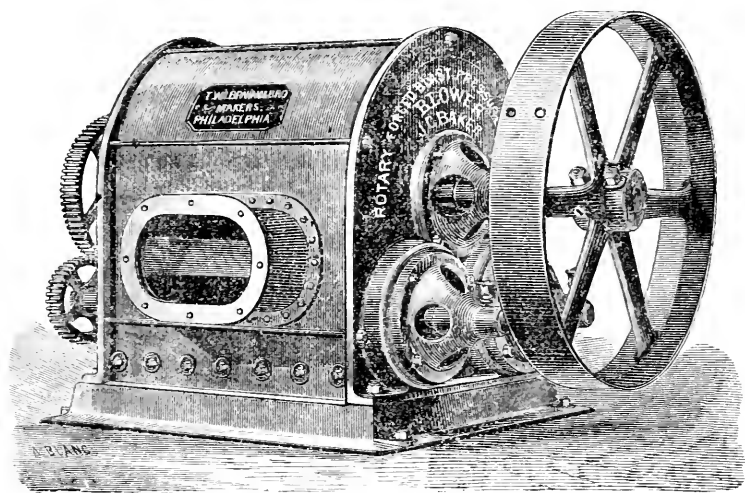


Fig. 1.

From an inspection of the engravings, the mechanism and operation of the machine will be evident; the sectional view (fig. 2), showing both its construction and the direction of the currents produced.

The following details will, however, sufficiently explain the invention: The external case of the blower is made of light boiler iron, formed up very truly and inserted slightly into the heads of the machine, said heads being made of cast-iron and faced off truly, and firmly secured to a substantial cast-iron bed plate; the two heads are

Bolted together longitudinally by iron rods on the outside of the case ;

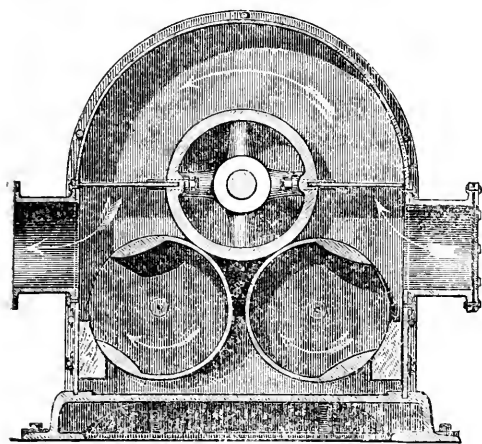


Fig. 2.

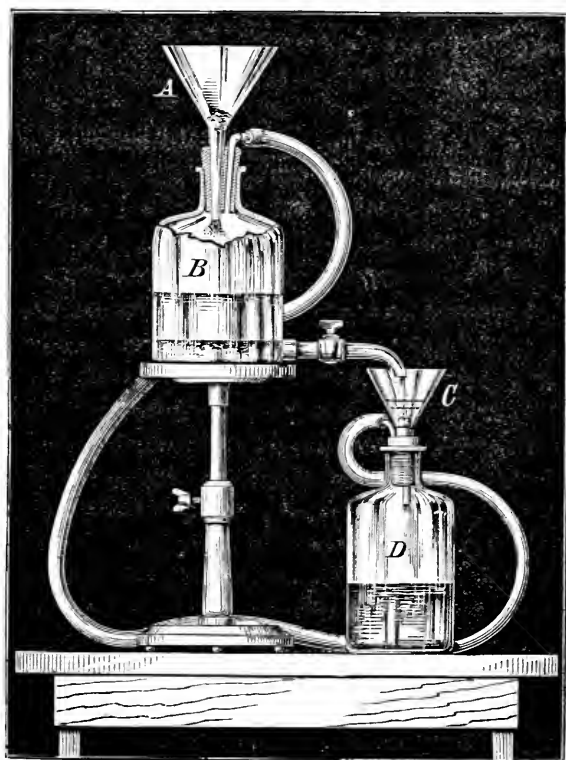
the drum concentric with the case, as well as the two lower drums, are each one solid iron casting and are all turned as true as possible ; the two lower drums only act as abutments alternately ; the opening in their sides is to allow free passage for the wings of the central drum. The gearing on the exterior of blower is for the purpose of retaining each drum in its proper position ; a wire guard or screen is

attached to the inlet to prevent anything from entering that might cause injury to the internal movements of the blower. The semi-annular space above the central drum is the chamber from which the air is expelled by the wings of the central drum in its revolutions ; this space, as it may be seen by the cut, is a section of a ring at all points of equal radius and area, and as the wings of the central drum continue to revolve at the same velocity, the air must be expelled in a nearly continuous stream.

It is claimed for this blower, amongst other things, that it will give a steadier blast than any other thus far produced, and that it is likewise quite superior in point of strength, fewness of parts, ease of motion, and durability.

Horse-Power of Steam Boilers.—We take pleasure in informing steam boiler makers and users, and the engineering public generally, that the various reports of the committee of this Institute, on the Horse-Power of Steam Boilers, together with the discussion on the same, have been published in pamphlet form, and will be found of value to those interested in the subject. A limited number are for sale at the Institute at 50 cents each, to pay for publication.

On the Purification of Mercury.—BY PROF. ALBERT R. LEEDS.—In investigations carried on in physical laboratories, and in the volumetric analysis of gases, a large quantity of mercury is employed, and as it is very readily contaminated, a method for its rapid and convenient purification is important. Such a method must provide for the removal of the three kind of impurities which are usually present: First, foreign metals, especially lead, zinc, and tin; secondly, common dirt and dust; and thirdly, water or other liquids.



The most convenient device hitherto employed was a long glass tube, into which the mercury was poured through a paper funnel, the funnel having a pin hole at the bottom, and serving to retain the dirt and dust. The tube was partly filled with dilute nitric acid, and was provided with a stop cock below, or with a bent tube, so that a short column of mercury might balance a long column of acid.

The device herein recommended consists of a glass funnel, *A*, ca-

pable of holding five or ten pounds of mercury, the tube of which is cut off at a point just below the stopper of the bottle, *B*. Cotton wool is jammed into the tube until it fills up the neck, and bulges out at the bottom of the funnel. A short glass tube bent at right angles passes likewise through the india rubber stopper, and is connected with a water air pump. The bottle is two-thirds filled with dilute nitric acid, (one part of acid and four or five parts of water). The impure mercury poured into the funnel, *A*, is drawn through the cotton plug in a multitude of streams, and passes as a fine rain through the acid below. The foreign metals, if not in too large quantities, are removed by solution in the acid, and the pure mercury collects below. It is then run off through the stop cock into a second funnel *C*; and, after being thoroughly dried by suction through another plug of cotton wool, it is caught and preserved in the bottle, *D*. A short time suffices for the almost automatic purification of a large quantity of mercury.—*From the Scientific American. Stevens' Institute of Technology, February, 1874.*

Comparative Value of Artificial Alizarine and Madder.

—The growing importance of the manufacture of artificial alizarine has several times of late been referred to in the *Journal*, as well as the probable effect of this increase on the cultivation of the madder. To such proportions has the alizarine manufacture attained, that the prevailing opinion has been to the effect that the near future would witness the total extinction of the madder culture.

In a recent report, however, of the Société Industrielle de Mulhouse, a somewhat different view is taken from that generally held.

The report maintains that the large demand for artificial alizarine will not seriously or permanently affect the normal consumption of madder; or, in other words, the proportion of pure madder used in the arts, before the introduction into commerce of extracts of madder, will remain unchanged. The artificial alizarine comes into competition with these extracts, but only to a limited extent; for it is declared that, while the violet shades which it produces are of superior beauty and brilliancy to those of the extracts, the reds it affords are inferior.

It seems that in the natural product there is a second coloring principle, namely, purpurine—to the presence of which the production of the fine orange reds is attributed. It has thus far been found impossible to reproduce the purpurine by artificial means; indeed, its

chemical constitution is yet but imperfectly known. The report concludes by expressing the opinion that the best tints will be produced by using the artificial alizarine and the madder extract combined—the latter being selected of a shade most nearly approaching orange.

The Preservation of Timber.—Before the French Academy, M. Boucherie, the son of the inventor of the system of injecting timber with sulphate of copper, recently declared that the tannate of protoxide iron does not possess the preservative properties attributed to it. He admits that it is a sure preventative against termites and worms, but he does not believe that it will preserve ligneous tissue, for, he declares, a minimum salt of iron, introduced into the vascular portion of wood, is rapidly converted into a maximum salt, a phenomenon accompanied invariably by the disorganization of the wood itself.

The author reported that he had experimented in dyeing balls black by injection of a solution of sulphate of protoxide of iron, of tannin and logwood, but he found that the wood was only preserved from decay when kept dry. The pyrolignite of iron, which possesses powerful antiseptic qualities, gave poor results. Balls, injected with sulphate of copper, were, on the contrary, perfectly preserved at the end of twenty-five years, and when analyzed, a notable quantity of the salt was found in them. He declared that it was an error to suppose that the sulphate of copper was very soluble, and that when exposed to the rain its preservative power disappeared after a certain time; the antiseptic agent, he declared, fixed itself in the elements of the wood, and could not be dissolved by washing; while cases of failure he attributed to a disease in the wood, the diseased tissue seeming to resist the sulphate.

An Oil Discovery of much importance is announced to have been made recently on the line of the Union Pacific railroad, about 800 miles west of Omaha, where the road crosses Green river. Here the approach of the road to the river is, for a considerable distance, through a cutting in rock, from 20 to 40 feet in depth. The discovery was accidentally made by the workmen engaged in the construction of the road, that the rock in question was oil-bearing. In heaping up fragments of the rock to protect the fire, it was observed that they ignited. Subsequent analysis and experiment, instituted at the instance of Mr. T. E. Sickles, the general superintendent of the road, resulted in establishing the fact that the rock was a shale quite rich

in mineral oils, yielding, by distillation, as much as 35 gallons of oil per ton of rock. The product which distills over is of two grades—one suitable for illumination and the other for lubrication. The deposits are said to extend over an area of more than 7,000 square miles, and it is predicted that they must form, in time, a possession of enormous value, inasmuch as the oil can be produced cheaply, and supplied to consumers on the Pacific coast, and those west of the Mississippi, cheaper than the oils of Pennsylvania or West Virginia can be transported to those localities. It is declared to be certain that these markets will very shortly be wholly supplied with oil from the newly discovered source, the proximity of the railroad affording ample transporting facilities for either the raw material or the manufactured product.

Exhibiting Photographs.—The *Scientific American* contains the following hint on the above subject, which may prove useful. The effect of photographic transparencies in the microscope, as well as on the screen, is greatly improved by placing a pale blue glass in the path of the illuminating beam. This artifice corrects the brown tone which they too often present, and gives depth and richness to the shadows.

Launch of the "City of Peking."—An event of much importance has recently transpired in the launch, at Chester, Pa., of one of the largest and most magnificent steamships ever constructed. The vessel in question, which is constructed throughout of American material, it is said, has but one superior in size, namely, the Great Eastern, and none in the quality of her materials or the elegance and perfection of her fittings. The ship was built for the Pacific Mail Steamship Line, and a second vessel, of similar construction and proportions, is now on the stocks for the same company. The "City of Peking" was built at the Delaware River Iron Ship Building and Engine Works, of which Mr. John Roach is President.

The dimensions and details of the vessel are as follows: length, 420 feet; beam 47 ft. 4 in.; tonnage, 6,000 tons; compound engines, 4,500 H. P.; propeller, 20 ft. 3 in. in diameter; four decks, and accommodations for two thousand passengers, fitted up in handsome style. The boilers are ten in number, and the estimated consumption of coal is placed at fifty or sixty tons per twenty-four hours. The steamship is entirely of iron, about five millions of pounds of metal having been used in the hull; the masts are four in number,

three of which are of iron, and used for ventilation, and she will be able to spread over 30,000 square feet of canvas. The speed of the vessel is stated at about $15\frac{1}{2}$ knots per hour. The occasion of the launching of this magnificent specimen of American mechanical skill was one of festivity and rejoicing to the people of the ancient city of Chester, and attracted many prominent visitors from other cities to witness the ceremony. The launch was successfully accomplished, and attended with all the ceremonies usual on similar occasions.

The Austrian Athenæum is an institution destined to survive the Vienna Exposition, as well as to serve as a memorial of that event. It has been founded in the interest and for the instruction of mechanics and workingmen, and constructed after the model of the *Conservatoire des Arts et Metiers*, in Paris. Large numbers of articles left by exhibitors have been transported thither, together with a great number of models and other instructive apparatus, and a library of several thousand volumes.

The Accident at Cambria Iron Works.—The following particulars concerning the accident at the Cambria Iron Works, at Johnstown, Pa., a few weeks ago, are given by the *Engineering and Mining Journal*:—An unnoticed sprul stood on the floor of the pit, and a little water had made its way there, too. Unfortunately, the sprul stood just on the spot where the ladle with its charge of steel was lowered to bring it down to the ingot moulds. The ladle struck the sprul and rested on it, the rack in which the ladle rests continuing to descend. When this was noticed, the crane was brought up, under the ladle again, but the cogs on the rack, instead of interlocking with those on the ladle gudgeon, came up butt against them. Probably there was a slip which brought the ladle forcibly down to its seat again; but at all events there was a break on one side, and the ladle swung down, letting its contents into the pool of water on the pit floor. There was a tremendous explosion, and a shower of melted steel was thrown about, causing one of the worst accidents known in Bessemer practice in this country. In the early days of Bessemer work it was not such an uncommon thing to make a casting on the floor of the pit instead of in the moulds; but in such cases time was usually allowed the workmen to put themselves in safety. On one occasion, however, we believe at the Kœnigshütte, in Germany, the man at the valve allowed the converter to tip too far, and the melted iron began to run out on the floor. Then he became agitated, and,

instead of reversing the valves, turned them further, so that a heavy stream of melted iron poured out, and several men were injured. It is traditional that this accident caused the abandonment of the Bessemer process at the works named.

Franklin Institute.

HALL OF THE INSTITUTE, March 18th, 1874.

The meeting came to order at the usual hour, with Vice-President Henry G. Morris in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the report of the Board of Managers, and reported that at their last meeting, held March 11th, 1874, the following donations to the Library had been read, viz. :

Annual Report on the State of the Finances to the Forty third Congress, first Session, December 1st, 1873. By Wm. A. Richardson. From the Hon. Secretary of the Treasury, Washington, D. C.

Annual Report of the Auditor-General of the State of Pennsylvania, etc., for the year 1872. From William A. Rolin, Esq., Philadelphia.

Reports of the Inspectors of Coal Mines of the Anthracite Region of Pennsylvania, for the years 1870 to 1872. From Wm. A. Rolin, Esq., Philadelphia.

The Giant Cities of Bashan and the Northern Border Land. From Eugene Nugent, Esq., Philadelphia.

The Coal Trade; a Compendium of Useful Information. From Frederick E. Saward, New York.

Quarterly Weather Report of the Meteorological Office, for October to December, 1872, and January to March, 1873. From the Meteorological Society, London.

Annual Report of the Chief of Ordnance to the Secretary of War, for the fiscal year ending June 30th, 1873. From the Chief of Ordnance U. S. Army, Washington, D. C.

Annales des Ponts et Chaussées for August, 1873. From the Editor, Paris.

Smithsonian Miscellaneous Collections, 255. The Constants of

Nature, Part 1. Compiled by F. W. Clarke, S. B. From the Smithsonian Institution, Washington, D. C.

Ordinance Memoranda, No. 14. Metallic Cartridges as Manufactured and Tested at the Frankford Arsenal, Philadelphia By Major T. J. Treadwell, Ord. Dept. From the author, Washington, D. C.

The Galvanometer and its Uses; a Manual for Electricians and Students. By C. J. Haskins, 1873. From D. Van Nostrand, New York.

Bulletin of the National Association of Wool Manufacturers, October—December, 1873. From the Association.

Astronomical and Meteorological Observations made during the year 1871 at the U. S. Naval Observatory. From Rear Admiral B. F. Sands, U. S. N., Washington, D. C.

Report on the Effects of the Sea Water and Exposure upon the Iron Pile Shafts of the Brandywine Shoal Lighthouse. By John D. Kurtz, Lt. Col. Engs., etc., and Micah R. Brown, Capt. of Engineers, Washington, D. C. From the authors.

Mr. William P. Tatham, from the Committee on Exhibitions, next presented a report of the steps taken by the Committee in the matter of holding an exhibition of Arts and Manufactures in the coming fall. After describing the premises, upon which it is proposed to hold the exhibition, particularly specifying the length and breadth of the building, and the amount of floor space which would be available for exhibition purposes, he read the following letter:

PENNSYLVANIA RAILROAD COMPANY,
PRESIDENT'S OFFICE, Philada., March 17th, 1874. }

WILLIAM P. TATHAM, Esq., *Chairman of Committee on Exhibitions.*

My Dear Sir:—I am directed by Mr. Thompson to say that the freight station at Thirteenth and Market streets will be at your disposal, for the use of the Franklin Institute as a place for holding an exhibition, on and after the first day of September next to the close of October; provided that we are not prevented from removal by circumstances now unforeseen.

Very respectfully,

STRICKLAND KNEASS,
Asst. to the President.

In consideration of the facilities placed at the disposal of the Institute by the letter just read, Mr. Tatham moved the following:

Resolved, That the Board of Managers are requested to hold an exhibition of American Arts and Manufactures the coming fall.

That the Board of Managers are requested to take measures to secure a guarantee fund to secure the Institute against loss; and

That the thanks of the Franklin Institute are due to the Pennsylvania Railroad Company for their prompt and liberal action, and that the President is requested to communicate this resolution to the President of the Company.

The resolutions were adopted.

Mr. Hector Orr moved a vote of thanks to the Committee for their prompt and efficient action in the matter submitted to them. Carried.

Mr. J. E. Mitchell expressed his satisfaction with the work of the Committee, and his estimation of the importance, both to the Institute and the city, of holding an exhibition as proposed.

Dr. Herricott, of Zanesville, Ohio, a visitor, expressed his gratification at the proposition of the Committee, and asked for information concerning the proposed conditions of admittance for those desiring to exhibit articles of manufacture.

Mr. E. Grey, of Chicago, Ill., then gave, by request, a statement of the space devoted to the late industrial exhibition in that city, and some details of its management and pecuniary success.

The Secretary then gave his monthly report on Novelties in Science and the Mechanic Arts, in the course of which Mr. Thomas Shaw described and illustrated, with the stereopticon, an improved relief block.—(*See Items and Novelties.*)

Mr. Hector Orr then announced the death of Mr. Thomas J. Weygant, a former officer of the Institute; and, after giving some detail of his life and his former activity and services as a member and officer of the Institute, moved the following resolutions:

Whereas, We have lost by death our late fellow-member and former manager of the Institute, Mr. THOMAS J. WEYGANT; therefore

Resolved, That the Institute hereby expresses sincere regret at the loss, and records its acknowledgment of the cheerful and faithful services of Mr. Weygant as a member and manager of the Franklin Institute.

Resolved, That a copy of these resolutions be addressed to the family of Mr. Weygant.

The resolutions were unanimously carried.

Mr. S. L. Wiegand then made a statement of the aid which he had received in illustrating his lectures before the Institute, through the kindness of Mr. Delamater, of New York, and moved, in consideration thereof, and the sending for use to the Institute, of one of the improved horizontal engines of the Rider pattern, manufactured by him, that the Secretary of the Institute be instructed to communicate

the thanks of the Institute to Mr. Delamater for his generous action in this matter. Carried.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary.*

NOTICE.

The attention of readers is called to the following extract from the minutes of the Board of Managers, held March 11th, 1874, which involves a change in the editorship of the Journal, to wit :

EXTRACT.

“ Mr. B. H. Moore, Chairman of the Committee on Publication, presented the following letter :

HALL OF THE FRANKLIN INSTITUTE, Philada., March 9th, 1874.

“ Gentlemen of the Committee on Publication :—

Having assumed other responsibilities, which make large demands upon my time, I fear that the attention which I will be able to bestow upon the Journal will be inadequate to its importance. I beg, therefore, to return the responsibility of its editorship into your hands, with the assurance that I will always look back to our harmonious relations with pleasure.

Very respectfully yours,

WILLIAM H. WAHL.’

“ On motion of Mr. B. H. Moore, it was

“ *Resolved*, That the resignation of Dr. William H. Wahl as editor of the Journal of the Franklin Institute be accepted, and that the thanks of the Board of Managers be tendered to him for his services in that capacity.’

“ On motion of Mr. Moore, seconded by Mr. Helm, it was further

“ *Resolved*, That the editorship of the Journal be tendered by the Committee on Publication to Prof. George F. Barker.”

Civil and Mechanical Engineering.

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS OF THE FRANKLIN INSTITUTE ON THE WESTINGHOUSE AIR-BRAKE.

HALL OF THE FRANKLIN INSTITUTE.

Philadelphia, Feb. 16th, 1874.

The Committee on Science and the Arts, constituted by the Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred for examination the Westinghouse Air-brake in its improved form, report, that they have been furnished by the inventor with every facility necessary for making a thorough examination and trial of this apparatus.

In its original and simplest form this brake consisted of a small steam engine placed on the locomotive, which, taking steam from the boiler, operated an air pump, which compressed air into a main reservoir secured beneath the cab. By a line of pipe extending back beneath the cars, and furnished between cars with a flexible hose, couplings and automatically acting valves, the compressed air was admitted at the pleasure of the engineer, who controlled its flow, by a three-way cock, to a series of brake cylinders, one under each car, the pistons of which were connected with and acted upon the ordinary brake levers and thus applied the brakes to the wheels. By reversing the three-way cock the air was allowed to escape from the cylinders and the brakes were off.

As quickness of action is of vital importance in the operation of a brake, and as it required an appreciable length of time, especially in long trains, for the air, even when under considerable pressure, to travel from the main reservoir to the brake cylinders to apply the brake, and also to pass back to the three-way cock to release them; the inventor made certain very important improvements, by means of which the compressed air can be admitted almost instantaneously into the brake cylinders, so as to apply the brakes without loss of time, and by the same means they can also be promptly released. The brakes can be so applied by the engineer, or by the conductor, or other person, from any part of the train. *Finally, these improvements secure this most remarkable and important result, viz: That the brakes*

will be instantly applied automatically in each car, (acting independently of all the others, and of train hands) should an axle break, or a car or the engine leave the track, or should the train be broken. The apparatus in this improved form is the one submitted to the Committee, and these improvements, in their general features, may be briefly described as follows :

An auxiliary reservoir for containing compressed air is placed on each car, close to the air cylinder. These auxiliary reservoirs are connected with the main reservoir by a pipe, without coupling valves, so that the same fluid pressure will be preserved in them as in the main reservoir. But the compressed air, before entering the auxiliary reservoirs, passes in each case through a valve box in which is a triple valve device, and from which valve box one port leads to the auxiliary reservoir, one to the brake cylinder, and a third to the open air. This triple valve is of such construction and arrangement with reference to the ports that, so long as the air pressure is kept up in the air pipe, the auxiliary reservoirs will be kept charged at the same pressure, and at the same time the ports intermediate between the brake cylinder and the external air will be open, and then, of course, the brakes will be off, and the train will be in running order. But on the air pressure in the air pipe being reduced, either by the engineer, who may open a cock for that purpose, or by the accidental rupture of the pipe, or by the accidental detaching of one or more cars, or by a trip device on each car, which, when a car jumps the track, shall automatically open a port in the air pipe ; in any such or other like contingency the ports between the air-charging pipe and each auxiliary reservoir will be instantaneously and automatically closed, as also the ports between the brake cylinders and the external air ; and also, at the same time, and by like instantaneous and automatic action. the ports will be opened between each auxiliary reservoir and its corresponding brake cylinder, so that the compressed air from the former shall flow directly into the latter, and operate without delay or loss of time, applying the brakes. By restoring the air pressure in the charging pipe, which is done by restoring connection with the main reservoir, the position of the triple valve is shifted so as to close communication between the auxiliary reservoirs and brake cylinders, and open communication from the latter to the external atmosphere. This operation is as quick in action as the other, and the brakes being thus released the train is again in running order.

The following full and accurate description, accompanied by draw-

ings and models, has been furnished by the inventor, in order to save the Committee the labor of preparing it. It gives a very full explanation of details of the apparatus.

The valve-box or case (fig. 3), is made in two or more parts, B, B^1, B^2 . The air-charging pipe which leads back from the main reservoir, is attached to the port G^2 , which latter then leads into the air chamber G . From the opposite chamber G^1 the port G^3 leads by a suitable pipe connection to the auxiliary reservoir, and a like pipe leads from the port H^1 to the brake cylinder. These devices are preferably arranged in such proximity to each other that the pipe connection will be short. The valve stem g has a limited motion longitudinally in the chambers G, G^1 . At or near one end it carries the valve a , which seats on the annular V-shaped seat a^1 by suitable packing on its lower face, so as when seated, to close the port a^1 . A series of wings arranged on this end of the stem g , act as guides in properly seating the valve a . A spring g^1 , arranged on the other end of the stem g , bearing against the cap B of the valve case and against the back face of the valve seat b , holds the valve a to its seat when not raised therefrom by air pressure. The air chambers G, G^1 are separated by means of a flexible diaphragm n , preferably made by sheet metal, the outer edge of which is compressed between the adjacent faces of the two parts B, B^1 , of the case annularly around the inner peripheries of the same, as shown in the drawings, with or without, but preferably with, interposed elastic packing rings or gaskets n^1, n^1 , of india rubber or other suitable material, such as will ensure an air-tight joint around the outer edge of the diaphragm, and permit of a comparatively free motion of the diaphragm in performing its function, and also prevent the wear which would be occasioned by the edge of the diaphragm working between metallic surfaces. From these annular compressing or packing surfaces, the parts B, B^1 of the case are so shaped inwardly as to give two annular and inwardly projecting flanges D, D^1 , the distance between which gradually increases toward their inner edges, but the slope of each is such, that so much of the diaphragm n as comes between them, shall rest on one or the other at the end of each stroke of the stem g , or at the extremity of its motion in either direction. The sloping surfaces of these flanges D, D^1 , constitute seats or rests to support the diaphragm after it has done its work, and thereby prevent its breaking. So much of the diaphragm as comes between these flanges may be corrugated annularly, if so desired, in which case such flanges should be a little

further apart, according to the depth of the corrugations—the object being to give the diaphragm a seat at the end of its motion in either direction. These flanges may extend inwardly any desired distance to, or short of, the compound nut or piston c , c^1 . But it is not essential that the diaphragm should rest on the flanges over the entire surfaces of the latter, but merely on sufficient surface to prevent too great deflection by the fluid pressure employed, and consequent straining.

The diaphragm n has an eye at the centre through which passes the stem g , and the annular edge of this eye is clamped firmly, as shown in the drawings between two rings which form parts of the compound nut or piston c , c^1 . The joint by which this clamping is effected, is preferably such that only the edge of the eye or hole of the diaphragm shall be gripped between such clamping rings—the adjacent surfaces of such clamping-rings being slightly beveled or flared away from the diaphragm, from the annular line of grip or clamp outwardly, as shown in the sectional view; and like packing can be employed here as at the outer edge of the diaphragm, if so desired, though probably it will seldom, if ever, be found necessary. The compound nut c , c^1 , is free to move on the stem g , lengthways of the latter, and its face c^1 is provided with suitable packing so as to make a tight joint when seated against the annular ring of the valve seat b . Commencing at a point a short distance from the upper valve seat b , the stem g is turned smaller or reduced in size, as at e , and is also slotted as indicated at e^1 . This reduction in the size of the stem g gives an annular air port e , by which communication is secured between the two chambers G , G^1 . The compound nut c , c^1 , which constitutes mechanically a piston, has an extension around the stem g , as shown at d , by means of which, in moving each way on the stem g , it alternately covers and uncovers the port e , and thereby closes and opens communication between the two chambers G , G^1 . The annular port e communicates with the valve-chamber G^1 by means of ports e^2 , which may be made in any desired number. Across the slot e^1 in the stem g , a cross-bar s is arranged, with its ends fixed in position in the adjacent walls of the nut c . From this slotted part e^1 a pin, s^1 , extends along through and lengthwise of the stem g , till it buts against the stem s^3 of the third valve s^2 .

The extension B^2 of the valve-box or case contains this valve s^2 , made with a suitable guide s^4 , which valve seats against a valve seat, so as to close an annular port u made therein. By means of this port,

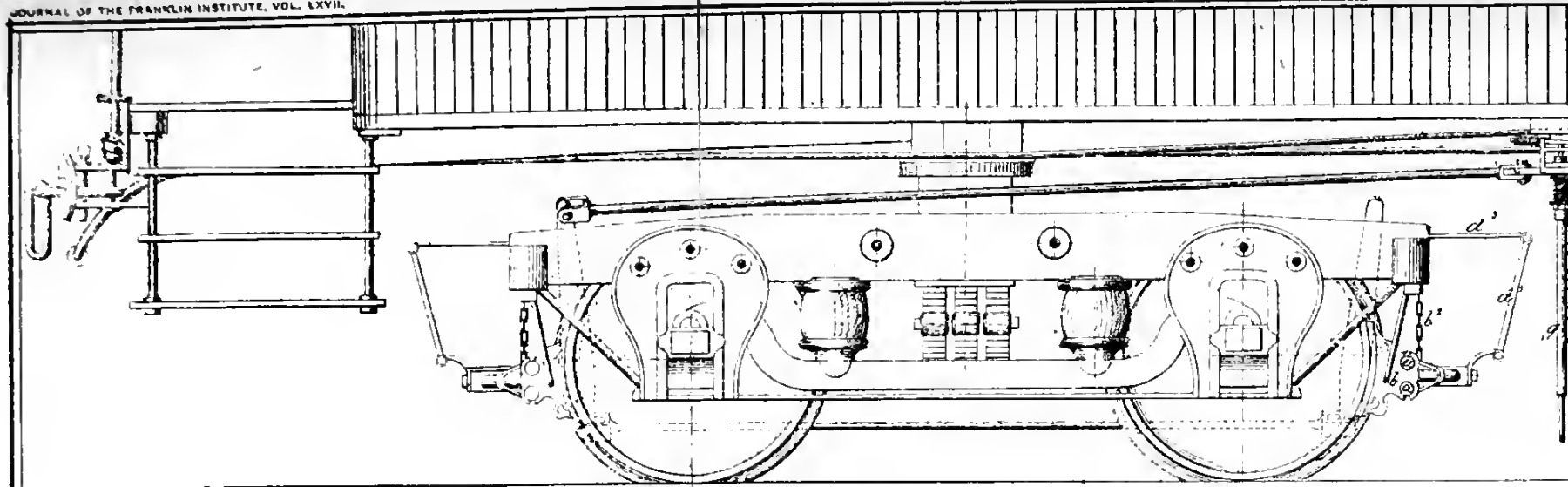


Fig. 1

WESTINGHOUSE AUTOMATIC SAFETY BRAKE

*Manufactured by The Westinghouse Air Brake Co.
Pittsburgh, Pa.*

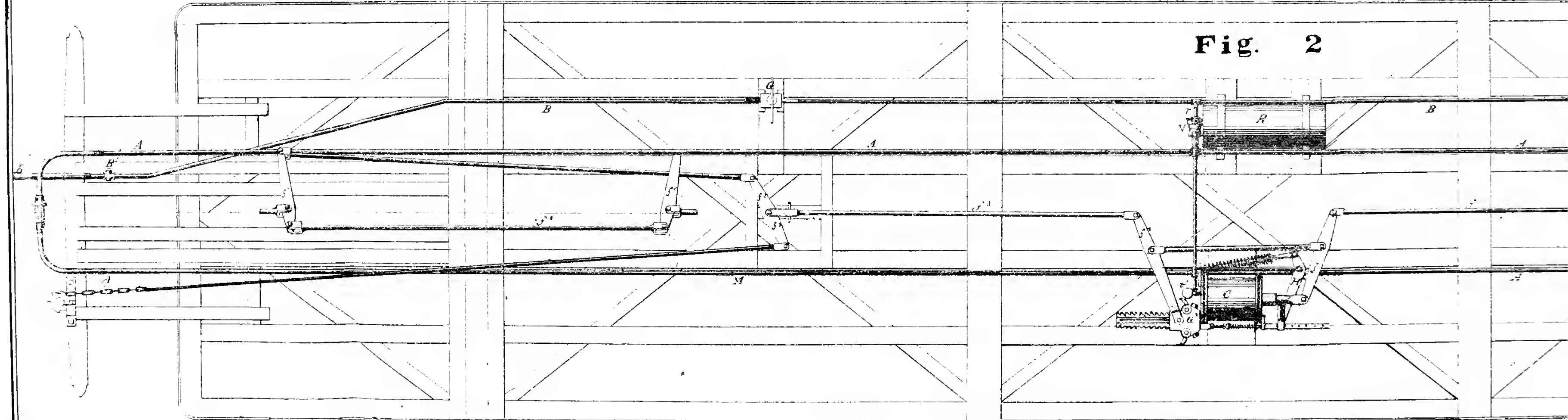
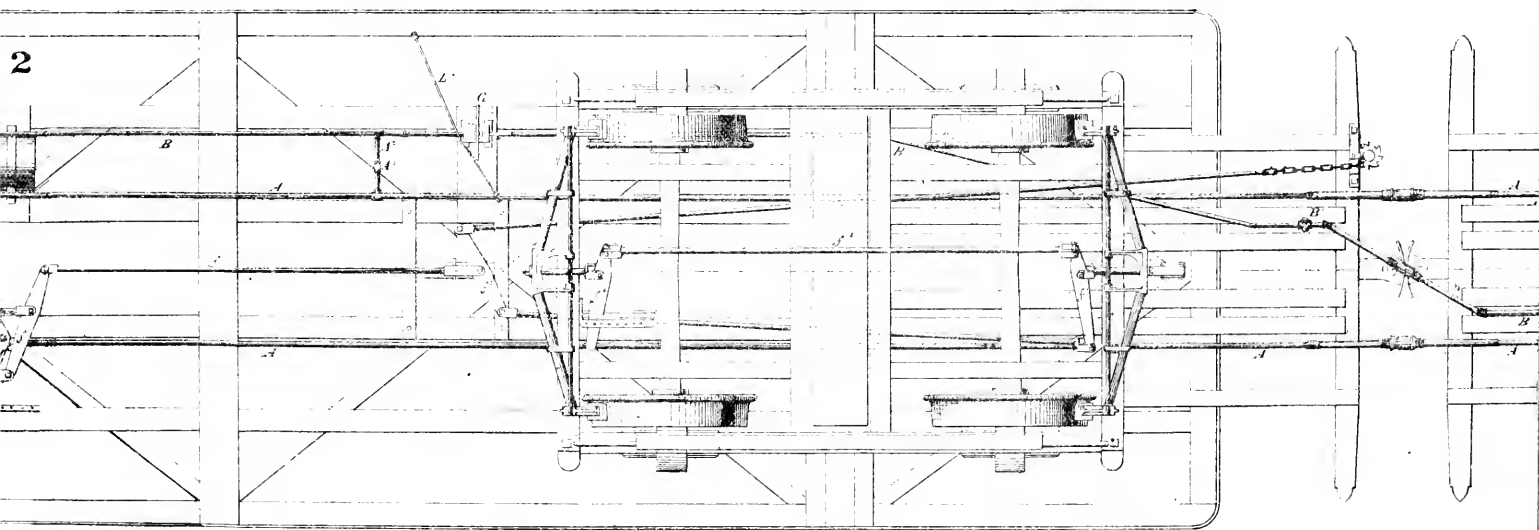
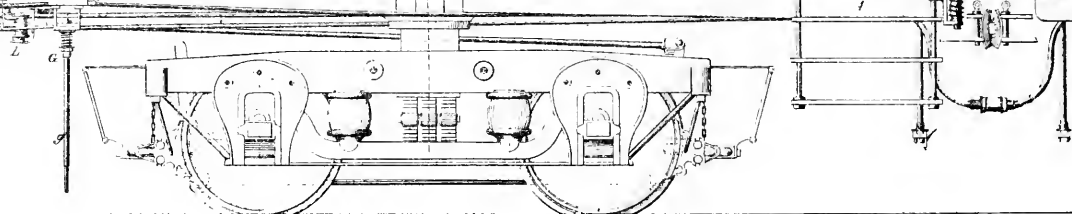


Fig. 2

SAFETY BRAKE

Westinghouse Air Brake Co.
Pittsburgh, Pa.





and the passages u^1 , u^2 , communication is effected (the valve s^2 being unseated) between the brake cylinder by the port H^1 , and the external atmosphere by the ports h^2 , for the purpose of allowing the compressed air to escape from the brake cylinder when the brakes are to be released or let off. The valve s^2 is seated and unseated by the action of the spring h , and the pin s^1 acting on the stem s^3 , as presently to be explained. To provide for an equilibrium of air pressure on both sides of the valve s^2 , the holes r are bored through it and its stem as shown.

The operation of the device described is as follows :

If air or other gas or fluid under pressure, be admitted by the port G^2 , it will, by the pressure it exerts on the flexible diaphragm n , cause the piston c , c^1 , with its diaphragm n , to be shifted on the stem g until it occupies about the position shown. The cross-bar s will then have opened the valve s^2 , and the valve a will be closed by means of the spring g^1 , or by fluid pressure or both ; also, the annular port e will be opened. In such case, the air or other fluid will pass, as indicated by the arrows, from the chamber G , along the ports e , e^2 , into the chamber G^1 , and out of the port G^3 to the auxiliary reservoir, whereby the auxiliary reservoir will be charged with compressed air of such density as it may be desired to store up for the purpose of operating the brakes. At the same time, by means already described, the valve s^2 is unseated, and thus a direct communication is opened from the brake cylinder, through the port H^1 , and ports h^2 , with the external atmosphere. The brakes are then off. As soon as the pressure on the opposite sides of the diaphragm n and compound nut c , c^1 , is equal or nearly so, the spring h in the lower part of the case, acting against the valve s^2 and through the stem s^3 , pin s^1 , and cross-bar s , will cause the piston c c^1 to slide upward on the stem g , and thereby cut off communication through the annular passage e , and will seat the valve s^2 so as to cut off the escape of air from the brake cylinder through the escape ports h^2 . Then, if the pressure exerted in the chamber G on the diaphragm n be reduced by allowing a portion of the air to escape from the charging-pipe, the pressure of the air or other gas, acting back through the port G^3 on the opposite side of the diaphragm n , will raise the piston c c^1 against the valve seat b , compress the spring g^1 , and by moving the stem g in the same direction, will lift the valve a from its seat a^1 , and thereby open communication from the chamber G^1 , through the port o^1 , with the port H^1 . The compressed air or other gas or fluid will then be free to pass

from the auxiliary reservoir, through the ports G^3 , o^1 , and H^1 , to the brake cylinder, so as to charge the same and apply the brakes in the usual way. The area of the opening through the port o^1 is regulated by the distance which the plug o is caused to move outwardly from the port. Hence, if the pressure be reduced but slightly at G^2 , the plug o will be raised but a short distance, and a small amount of compressed air or other fluid will be allowed to pass through and out at the port H^1 . When the equilibrium is thereby restored in the chambers G , G^1 , the valve a will resume its seat and close communication. If the pressure in the chamber G be materially increased, the valve s^2 will be unseated, as already described, and an open communication be made from the brake cylinder through the port H^1 and h^2 , to the external atmosphere. By the use of the taper plug o , in the manner described, and by regulating, as can easily be done by the use of suitable cocks, the amount of pressure in the chambers G , G^1 , it is easy to regulate the amount or density of the air which is permitted to flow through the ports o^1 into the brake cylinder, and consequently easy to regulate and adjust, at all times, the force with which the brakes are applied, and such force may be varied from the maximum power of the brakes down to the fractional part of a pound, in excess of ordinary atmospheric pressure.

In the use of the apparatus such as that to which this improvement appertains, when a car is detached from a train, the charging pipe should be closed at each end before the car is detached, to prevent the brakes being applied or "set" by the reduction of the pressure. In such case, if, as will sometimes happen, the air leaks slightly from the charging pipe, the valve a will be raised slightly from its seat, and the air pressure will pass slowly from the reservoir by the port G^3 , through the port o^1 , and by the port H^1 to the brake-cylinder, and thereby set the brakes. To prevent this result, a relief-valve is arranged on the pipe H , which latter leads from the port H^1 to the brake-cylinder. This valve consists of a cylindrical box R , having a cap R^1 with a small port r^1 bored therein, and faced with a rubber or other suitable packing r^2 . At its opposite end it communicates with the bore of the pipe H by a small port r^3 . In the chamber of the case R is a valve R^2 working loosely therein, and having on its upper end a seat of suitable form, so that when forced up by the ordinary pressure in working the brakes, it will seat against the packing r^2 and effectually close the port r^1 . But when the pressure in the pipe H is only such as may result from leakage, as above mentioned,

such pressure will pass out through the port r^3 , and, escaping through small grooves r^4 , or tilting the valve R^2 off its lower seat, will pass up around it without seating it upward. The amount of pressure which may in this manner be allowed to escape without the application of the brakes, may be varied at pleasure by varying the size and weight of the valve R^2 .

For greater convenience and facility in opening and closing the valve case B , B^1 , a fastening device has also been devised, as shown in the drawings. The part B fits on to the part B^1 like a cap, and is held in place by means of eye-bolts m , which fit into a recess, or between lugs, as shown. These eye-bolts are held in place at one end by means of pins m^1 , which pass through the eye-ends of the bolts and through lugs m^2 on the one part B^1 of the case, and said bolts are threaded at the opposite ends, and secured so as to hold the two parts of the valve case together by means of screw-nuts m^3 . The threaded ends of the bolts project a short distance beyond the outer faces of the nuts, when the latter are screwed down tight, and such projecting ends are rivetted or upset slightly, so that while leaving room for the nuts m^3 to be unscrewed sufficiently for the bolts m to swing outwardly from the recesses in the cap B —turning for that purpose like hinges on the pins m^1 —they cannot be screwed off entirely so as to be lost, but will always be in place for use. Thus a convenient and speedy mode is provided of opening the valve-case B , B^1 , for cleaning, repairing, adjusting or replacing any of the devices included therein, without disconnecting or straining the pipes.

In the apparatus described, each auxiliary reservoir has about four times the capacity of the corresponding brake-cylinder. The charging pipe, which is made of three-quarter inch gas pipe, extends from the main reservoir back under the whole train, and is provided with a three-way cock on the engine, by which the entire apparatus for ordinary braking purposes is placed under the control of the engineer. This pipe is, between the cars, provided with flexible sections, on the outer side of which are couplings, which are counterparts or duplicates of each other. These couplings have no valves for retaining, when uncoupled, the compressed air; but a cock is inserted in the pipe, at or near each end of each car, for closing the pipe at the rear end of the train, and also at each end of a car, when such car is detached from a train.

The advantage of an instantaneous application of the brakes at the will of the engineer is obvious. In the system heretofore in use, the

pressure has to be transmitted back through the train. In the improvement just described, the requisite pressure is kept up throughout the train, ready to be put into operation. In the former case, 1,200 cubic inches of compressed air at 35 lbs. pressure per square inch for each car, or 2,800 cubic inches at atmospheric pressure, have to be transmitted back from car to car to apply the brakes effectually. In the latter case, a reduction of 15 lbs. in the pressure of the air in the pipe (which is equivalent to the pressure of *one* atmosphere) is all that is necessary to effect the same result. This reduction of pressure is equivalent to the transmittal of 360 cubic inches of air for each car at atmospheric pressure. The saving of time in applying the brakes will then be approximately in the proportion of the quantity of air transmitted, or as 2,800 is to 360.

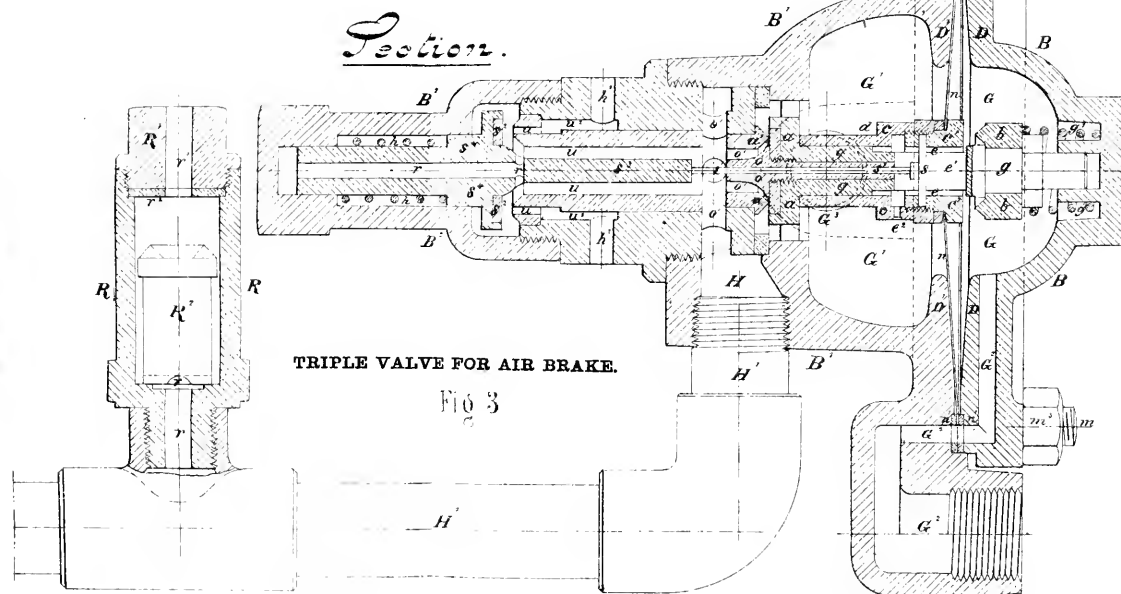
This relative proportion is affected only by the friction of the air in passing through the pipes, and this element is comparatively inappreciable as affecting the result. By arranging the auxiliary reservoir and the brake-cylinder of each car in close proximity with each other, the time required for the air to pass from the former to the latter will be so small as to be unimportant; and as a train, moving at the rate of forty miles per hour, passes over fifty-eight and two-thirds feet per second, or a little more than the length of an ordinary passenger car, it will be obvious that, in case of danger, every second of time saved in the application of the brakes immeasurably reduces the chances of disaster, and multiplies, in a geometrical ratio, the probabilities of safety to both travelers and train.

From the construction of the apparatus, it will be obvious that its durability is limited only by the number of times that the valves described will bear the required operation in the application and release of the brakes. All the material being of metal, will not be appreciably affected by age.

To test thoroughly the number of operations that would be required to destroy the apparatus or any breakable part of the same, this triple-valve device was arranged in connection with a charging pipe and brake-cylinders as in a train, while a three-way cock on the pipe was operated by machinery in like manner as in ordinary use for braking purposes. After the reservoirs were charged with compressed air at ordinary working pressure, the machinery which opened and closed the three-way cock was set in motion, and the triple-valve began its work. After 309,000 *strokes* in opening and closing the ports, which was equivalent to applying and releasing the brakes that number of

WESTINGHOUSE AUTOMATIC SAFETY BRAKE

*Manufactured by The Westinghouse Air Brake Co.
Pittsburgh, Pa.*



TRIPLE VALVE FOR AIR BRAKE.

Fig. 3

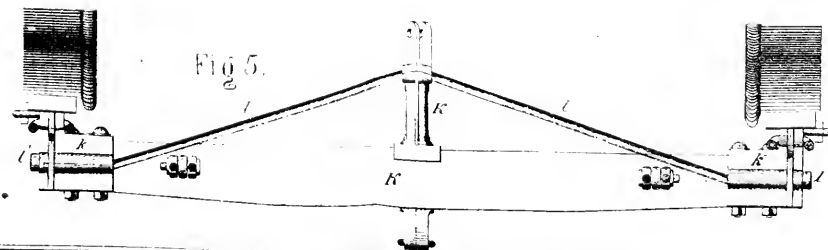


Fig 5.

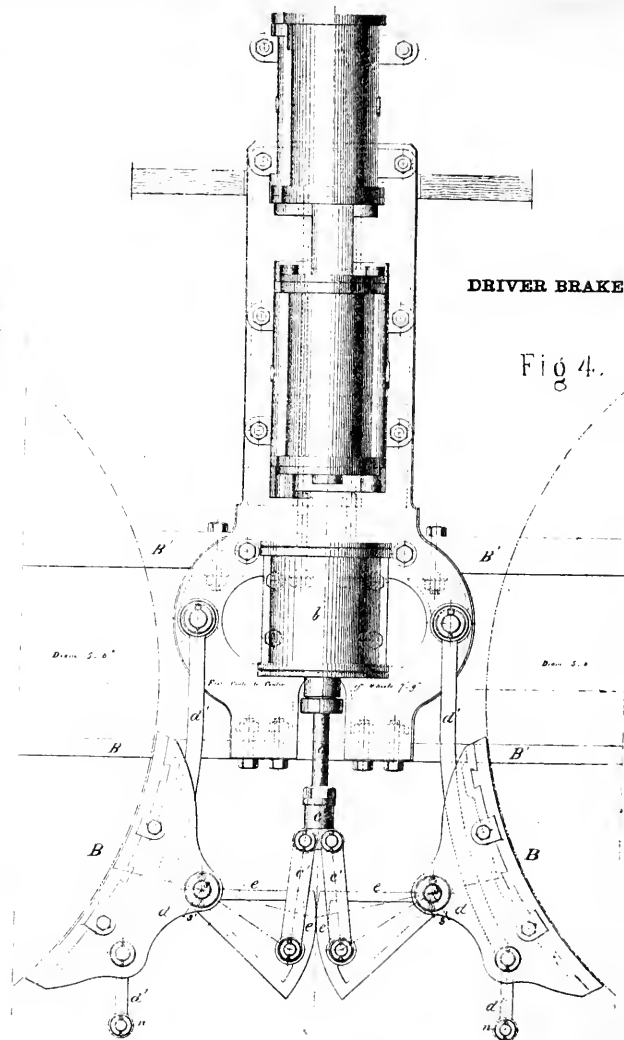


Fig 4.

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times, it was still found in perfect working order, so far as it could be ascertained from its operation. Upon examination it was found that the diaphragm n showed signs of cracking at a point between the rubber packing rings n^1 , n^1 . The other parts of the triple-valve made 460,000 strokes without any indication of failure. These experiments have been continued at great length, and in no case has the triple-valve failed to perform its work promptly and effectively. In these tests, the pistons of the brake-cylinder receive a full and complete stroke, so that the shock, and, of course, the strain on the triple-valve, is more severe than in ordinary train use.

The triple valve above described is inserted at V, Fig. 2, in which figure B is the charging pipe, R the auxiliary reservoir, and C the brake cylinder. Figs. 1 and 2 also show at A, A the brake pipes of the old Westinghouse Apparatus as heretofore in general use. In these figures they are, for convenience of illustration, shown as combined with the automatic system on the same car; and when combined in this way either system of apparatus may be used at pleasure by the interposition of a double ended check valve at v^1 . At G, Figs. 1 and 2, a trip valve and tripping arm is placed so as to apply the brakes automatically in case of the derailment of a car. Also, by a conductor's cord attached to a lever L^3 , means are provided to enable the conductor to apply the brakes at his pleasure from any car on the train. The arrangement of the brake rods and levers will be readily understood from the drawings without further description.

Another valuable improvement which has been made in the Westinghouse system of apparatus relates to brakes for the driver wheels of locomotives. This feature of the system is illustrated in figure 4, in which the ordinary drive wheels are shown at B, B, and B^1 indicates portions of the frame work of the locomotive. The brakes proper, d , are recessed on their rear faces and are pivoted to the hangers, d^1 , below and a little forward of their centres of gravity, so as naturally and by their own weight to swing clear of the wheels. To these brake-shoes, blocks or holders, d , are pivoted the eccentric-faced segment levers, e , e , in such position that their circular or curved faces or peripheries shall work against each other or against a block or other desired device placed between them. At any desired points in the direction of the length of their curved peripheries, and preferably near the lower ends of the same, the connecting rods, or stirrups, e^1 , are pivoted, which latter at their upper ends are jointed to the lower end of the piston stem, c . The segment levers,

e , are somewhat eccentric, their working faces at the lower ends being somewhat further from their centres of motion than such faces are at their upper ends. In the drawings, s indicates the centre of motion in each, and s^1 the centre of curvature. The amount of this eccentricity may be varied at pleasure.

This apparatus, together with the brake cylinder, b , is duplicated on the opposite side of the locomotive. The compressed air is admitted by a pipe from the main reservoir, with an interposed three-way cock, beneath the piston in the brake cylinders b , and by the upward thrust imparted thereby to the piston stem c , shifts the segment levers e , so as, acting on the principle of the toggle joint, to apply the brakes effectually to the wheels. By this construction, in fact, the ordinary advantages of the toggle joint are secured along with a uniform, or nearly uniform, application of the power at all points of the stroke, until the brake shoes are worn entirely away. Where the distance between the drivers, B, B , is too small to admit of the introduction and use of both the segment levers, e, e , one only may be used, pivoted to one of the brake blocks, and with its eccentric face working against a friction roller pivoted to the other brake block at s .

It may safely be said that the time is not far distant when the wonder will be that driver brakes could ever have been dispensed with. In an ordinary passenger train, of say a locomotive, tender and six cars, the aggregate weight of the cars may be stated in round numbers at ninety tons, and that of the locomotive and tender at say forty-five tons, or, in other words, about one-third the weight of passenger rolling stock has been used without any brake power whatever. Thirty-three per centum of the braking power applied to the cars is expended in stopping the locomotive and tender, with a consequent enormous and undue strain on the couplings, which, of course, is greatest between the engine and tender and decreases backwards toward the rear of the train. This strain, of course, tends to pull the train apart and leave the locomotive free of control except by reversal of the engine. Also if, as heretofore, the car brakes are applied with sufficient power not only to arrest the motion of the cars, but also with fifty per centum more power in order to stop the locomotive, it is obvious that the car brakes, wheels and trucks, must be made enough heavier and stronger than would otherwise be required, in order to enable them to resist this fifty per cent. of additional strain. Or, if they are still made as strong in this respect as heretofore, the use of driver brakes would enable the engineer to stop his

train so much the quicker; and this efficiency of the driver brakes is further augmented from the fact that the adhesive power of the steel tires of the drivers on the rails is so great, as compared with that of cast iron wheels, that a greatly increased braking power may be applied to the drivers without sliding them; also, as a further consideration, the locomotive is the first to run into danger, it occupies the position where danger is greatest, and, except in great catastrophes, the chief loss to the company is occasioned by injury to or destruction of the locomotive. And these elements of danger are augmented when a train breaks in two, since then the aggregate braking power of the train is diminished in proportion to the number of cars detached. It would seem that, in a perfect system of braking apparatus, the braking power applied should be distributed, as near as may be, on locomotive, tender and cars in proportion to the weight of each. This improvement is intended to be a step in this direction.

The construction of our locomotives is such that the ordinary brake beam cannot be employed, nor can the power to operate it effectively be got to it without great expense. The distance between the drivers is usually small—too small for any but the simplest apparatus, and to meet the requirements such apparatus must act quickly, surely and with great power. If operated from above, allowance must be made for the vertical motion of the engine on its springs. This motion, though small, is so great as to render inapplicable for applying the power any device which has only a fixed length of motion, or which, after completing its motion, has no “give” or elasticity. An inspection of the drawings will show that all these requirements are fully met in the Westinghouse improvement, and especially as to the last one named, the elasticity of the compressed air in the brake cylinder takes up any inequalities which may arise from the motion of the engine on its springs or other like causes.

Fig. 5 shows the construction of a new brake beam, which Mr. Westinghouse is now introducing in connection with his brake. It consists of the usual wooden bar *K*, on the ends of which are attached cast metal boxes *k*. The tension rod *l* has upset heads *l*¹, which bear against the outer ends of the boxes. The strain in braking is then, by the post *K*¹, divided between the bar *K* and the tension rod *l*. The shoe-holders are cast with the boxes, and the shoes are made removable and reversible. By means of a spring *L* in connection with the links, by which the brake beam is hung, provision is made by which the brake shoes, while moving from the wheels, will

at each end move a uniform distance, or, in other words, when the brakes are off, the shoes will swing wholly clear of the wheels throughout the entire length of their working faces.

EXPERIMENTS.

A train fitted with the improved apparatus, and consisting of an engine, tender and seven passenger cars, was brought from Pittsburg, and placed at the disposition of the Committee on the 20th of May last. It was understood that the air-brake apparatus was not made for this especial occasion, but was like those of the same kind in ordinary use upon the Pennsylvania Railroad.

This train was taken in the afternoon of the day mentioned to a part of the road suitable for the purpose, about fifteen miles from the city, and the experiments about to be described were made under the direction of the Committee and in the presence of a number of other persons interested in railroad matters, who had been invited to witness the trials. There were perhaps fifty or sixty persons in all, and they constituted the living load of the train.

The speed of the train in all the experiments was estimated, by noting the time in passing mile posts, with a considerable degree of accuracy, by members of the committee. It is believed the speed is rather under than over-estimated.

The distance run after applying brakes on giving signals, was ascertained by measurement with a tape-line from a stick with a small red flag upon it, which was thrown from the train at the moment of giving the signal or applying the brakes. A correction has been made for the space passed over by the train while the flag was falling to the ground.

The time consumed in bringing the train to rest was accurately ascertained by means of a stop-watch, which indicated to the fifth of a second.

For the "grades," the Committee are indebted to the courtesy of Mr. W. H. Wilson, Chief Engineer of the Pennsylvania Railroad.

First Experiment.—Stop to be made by the engineer in answer to a signal given by the conductor with the bell-rope. Distance to be measured from a flag thrown from the engine simultaneously with the application of the brakes.

Result.—The train came to a full stop in sixteen (16) seconds, having run a distance of 503 feet from the flag. The speed was thirty miles an hour, *up* a grade of 29.6 feet per mile. The time

required for the flag to reach the ground after being thrown out was about seven-tenths of a second, and adding the distance passed over by the train in this time, say 44 feet, we have 547 feet as the distance passed over by the train after the brakes were applied, and being only a little more than the length of the train.

Second Experiment.—Stop to be made by applying the brake from the interior of one of the cars. Time and distance ascertained as before.

Result.—The train came to a full stop in fifteen (15) seconds, having having run a distance of 506 feet. The speed was between 30 and 35 miles per hour, down a grade of 31.7 feet per mile. Assuming the speed to have been 32 miles per hour, there should be added for distance run, during the falling of the flag, 47 feet, making the actual distance run by the train after application of the brakes 553 feet.

Third Experiment.—Stop to be made by severing the train. Brakes working automatically; flag to be thrown out at the instant of parting.

Result.—In this case the train was running at a speed of full thirty miles per hour, down a grade of 26 feet per mile, when five rear cars were detached. These cars came to a full stop in 11.8 seconds from the time the train was cut, having run a distance of 367 feet, or, with the allowance for falling of the flag, 411 feet. The forward part of the train came to rest a very short distance in advance.

Fourth Experiment.—Similar to the last, except that the engine alone was severed from the train. Brakes acting automatically, as in the last experiment. The speed was forty miles an hour down a grade of 28.2 feet per mile. The train came to a rest in $10\frac{1}{2}$ seconds, having run by the flag 265 feet, or, with allowance for time of falling, 323 feet.

This experiment was then repeated, the Committee and others having left the cars to witness it while standing along side the track. The train came to rest in $10\frac{1}{2}$ seconds, running 291 feet from the spot where the brakes were applied. The speed was very great, and was judged to be forty-five miles per hour. The stop at this unusual speed was made in about the length of six cars.

Fifth Experiment.—Stop to be made from one of the cars. The engine to remain wide open, working ahead.

Result.—The train came to a full stop in 15.8 seconds, having run from the flag 502 feet, or, with allowance as before, 555 feet. The speed was thirty-six (36) miles per hour, up a grade of 29.6 feet per mile.

Sixth Experiment.—To show how quickly the train could be got in motion again after stopping, two stops were made in succession, and the interval of rest in each case was timed by the Committee. After the first stop, the train was in motion again in $4\frac{1}{2}$ seconds, and after the second stop in 2·8 seconds.

It was stated that the engineer did not fully understand his instructions when making his first stop, and the difference in time is thus accounted for. The rails were slightly wet.

Seventh Experiment—was scarcely necessary, as it was simply to show that the triggers which open the valves and apply the brakes when the cars leave the track would act when they meet an obstruction. This was so obvious as not to require demonstration.

This completes the record of the experiments made by the Committee. They were all entirely satisfactory, and they demonstrate very clearly the extraordinary efficiency of this brake apparatus.

The first experiment shows that a train, moving down a grade of about 30 feet per mile, at a speed of 30 miles per hour, may be stopped by the engineer in about a quarter of a minute of time, and in a distance of less than 550 feet.

The second experiment shows that a train may be stopped (by simply pulling a cord in any part of it), when going down a grade of about 32 feet per mile, at a speed of about 32 miles per hour, in a quarter of a minute of time, and in a distance of 550 feet, or less than its own length.

The third experiment is more remarkable. It shows that if the cars become detached, or the train be broken in any way, the brakes are instantly applied automatically. The train, and each car in the train, as it were, takes care of itself, and nothing depends upon the promptness, or presence of mind, or judgment of the train hands.

It is obvious that in this way, the brakes are applied more promptly than would be possible by the train hands, and under circumstances where instant action is extremely important. The same action would take place if an axle or wheel were to break, or if the cars or any one of them should leave the track.

The fourth experiment was similar to the last, and gave similar results.

The fifth experiment shows the extraordinary efficiency of this brake to control the train. With the engine working ahead, with the throttle wide open, and at a speed of about 36 miles per hour, up a grade of 30 feet per mile, the train was stopped in about a quarter of a minute, and in a distance of 555 feet.

In all these experiments, the cars were brought to rest quietly, without shock, or any action which would disturb passengers, or throw them from their seats.

The Committee have given consideration to the question of the probable durability of this apparatus, and to its liability to derangement. Considering what this brake accomplishes, and reminding that there is a complete self-acting brake in each car, this apparatus may be considered as simple, and they can see no reason why it should get out of order, or be unreliable if it is cared for with reasonable attention. It is of course more complicated than the common hand brake, but it is vastly more effectual and greatly diminishes the risk of injury to passengers and rolling stock.

A few figures will show the importance of the prompt action of the brake. If a train be running at the rate of 35 miles per hour, (a very common speed,) it passes over 3,080 feet per minute, or, about the length of an ordinary car, in one second. If two trains approaching each other at that speed should come into collision, it would require only half a second to "telescope" one car into another its full length. A half second of time might therefore jeopardize the lives of fifty or sixty passengers.

In conclusion, the Committee say that these experiments have demonstrated to them the extraordinary efficiency of this apparatus, and they especially call attention to the value and importance of the arrangement which secures the instant automatic application of the brakes on the engine and on each car of the train, independently of the train hand, in certain contingencies, which are of common occurrence and are the cause of frequently disastrous accidents.

The Committee believe that by contriving and introducing this apparatus, Mr. Westinghouse has become a great public benefactor, and deserves the gratitude of the traveling public at least. They believe that his inventions are worthy of, and should receive the award of the Scott's Legacy medal, and they therefore conclude this report by proposing the adoption of the following resolutions :

Resolved, That the report of the Sub-Committee, appointed to examine and report upon the Westinghouse Air Brake, be accepted and be referred to the Committee on Publication, to print in the *Journal of the Franklin Institute* such part thereof as they may deem proper or necessary to make known to the public the result of this examination.

Resolved, That this Committee (of Science and Arts) recommend to

the Board of Managers of the Institute, that they make the award of John Scott's Legacy Premium and Medal to George Westinghouse, Jr., of Pittsburgh, Pa., for his improvements in Air Brakes for railway trains.

All of which is most respectfully submitted.

JOHN H. TOWNE,	} <i>Committee.</i>
S. W. ROBERTS,	
J. S. BANCROFT,	
CHARLES M. CRESSON, M. D.	

By order of the Committee,

D. S. HOLMAN, *Actuary.*

[Entered according to the act of Congress, in the year 1873, by John Richards, in the office of the Librarian of Congress at Washington.]

THE PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

By J. RICHARDS, Mechanical Engineer.

(Continued from page 174.)

MACHINERY FOR TRANSPORTATION AND FOR MOVING AND HANDLING MATERIAL.

Steam machinery, as applied to the transport of material and travel, in navigation and by railways, comprises a large share of all that is constructed; and when we consider that this vast interest of steam transport is less than a century old, and estimate its present and possible future influence on human affairs, we begin to realize the relation that mechanical science bears to modern civilization.

To follow out the application of power to the propulsion of vessels and trains, with the many abstruse conditions that would, of necessity, be involved, would be to carry this work far beyond the limits within which it is most likely to be useful to the apprentice; besides, it would be going beyond what can properly be termed shop manipulation.

Marine and railway engineering have engrossed the best talent in the world, investigation and research have been expended upon these subjects in a degree commensurate with their importance, and it would be hard to suggest a single want in the many able text-books that have been prepared upon the subjects.

Marine and railway engineering are sciences that may, in a sense,

be separated from the ordinary constructive arts, and studied at the end of, a course in general mechanical engineering, but are hardly proper subjects for an apprentice to take up at the beginning of a course.

In treating of machinery for transport, as a class, the subject, as far as treated here, will be confined to moving and handling material as one of the processes of manufacturing, especially in connection with machine construction.

If the amount of time, expense, labor and machinery devoted to handling material in machine shops is estimated, it becomes a matter of astonishment to as many as have not previously investigated the matter; as an item of expense the handling often exceeds the fitting on large pieces, and in the heavier class of work demands the most careful attention to secure economical manipulation.

It will be well for an apprentice to begin at once, as soon as he commences his course, to note this matter of handling material, watching the operation of cranes, hoists, trucks, tackle, rollers; in short, everything that has to do with moving and handling.

The machinery and appliances in ordinary use are simple enough in a mechanical sense, but the principles of handling material are by no means as plain or easy to understand.

The diversity of practice seen in the various plans of handling and lifting weights fully attests this last proposition, and it is questionable whether there is any other branch of mechanical engineering that is treated in a less scientific way than machinery of this class; I do not allude to the mechanism of cranes and other devices which are usually well proportioned and generally well arranged, but to the adaptation of such machinery with reference to special or local conditions.

There are certain inherent difficulties that have to be encountered in the construction and operation of machinery for lifting and handling that are peculiar to it as a class; among these difficulties is the transmission of power to movable mechanism, the intermittent and irregular application of power, severe strains, also the liability to accidents and breakage from such machinery being controlled by the judgment of an operator.

Ordinary machinery, on the reverse, is stationary, consumes a regular amount of power, is not subjected to such uncertain strains, and as a rule acts without its operation being controlled by the will of attendants.

The functions required in machinery for handling material in a machine shop corresponds very nearly to those of the human hands. Nature has exceeded man in the adaptation of lifting and handling mechanism; in fact, we cannot conceive of anything more perfect than the human hands for handling material—a duty that forms a great share of all that we term labor.

As machinery for handling material, the hands may be considered as capable of exerting force in any direction, vertically, horizontally or at any angle, moving at various rates of speed, as the conditions may require, and with varying force within the limits of human strength. These functions enable us to pick up or lay down a weight slowly or carefully, but to transport it at a rapid rate to save time, to move it in any direction, and without the least waste of power, unless it be in ascending with a load when the body has to be carried up and down at the same time. The travelling swing cranes that are sometimes used in machine fitting establishments are the nearest approach that has been made to the human frame in the way of handling mechanism; they, however, lack that very important feature of a movement the speed of which graduated at will.

In handling a weight with the hands it is carefully raised, and laid down with care, but moved as rapidly as possible throughout the intervening distance.

It is evident that machinery of any kind for handling and lifting, that moves at a uniform rate of speed, and this rate of speed adapted, as it must be, to the conditions of starting or depositing a load, much time must be lost in the transit, especially when the load is moved for a considerable distance. This uniform speed is perhaps the greatest defect in the lifting machinery in common use, at least in such lifting machinery as is driven by power.

The lessons of nature in this particular have not been disregarded, however, and we find that the attention of engineers has been given to this principle of variable speed to be controlled at will.

The hydraulic cranes of Sir William Armstrong employ this principle in the most effective manner, not only securing rapid transit of loads when lifted, but depositing or adjusting them with a care and precision unknown to mechanism, that is geared positively or operated by friction breaks.

The principles of all mechanism for handling loads should be such as to place the power, the rate of movement, and the direction of the force, within the control of an operator, which the reader can see is in substance the same thing as the power of the hands.

The safety, simplicity and perfect action of hydraulic machinery has already led its extensive use for moving and lifting weights, and it is fair to assume that the importance and success of this invention fully entitles it to be called one of the most important that has been made in mechanical engineering during the past fifty years.

The application of hydraulic force in operating the machinery used in the Bessemer processes for steel manufacture, is one of the best examples to illustrate the advantages and principles of the system. As there are published drawings and descriptions of Bessemer steel plant by Mr. Holly and other engineers, the apprentice is recommended to study the hydraulic apparatus as applied to handling material in these examples, keeping continually in view the principles of action as differing from ordinary cranes or hoists.

There is, however, a defective principle in hydraulic machinery that must be taken into account in comparison with positively geared mechanism, and which in many cases will overbalance any gain derived from its superior action. I allude to the loss of power incident to dealing with an inelastic medium, and when the amount of force expended is constant, regardless of the resistance offered. A hydraulic crane, for instance, uses power in proportion to its movement, instead of as the amount of duty performed; it takes the same quantity of water to fill the cylinders, whether the water exert much or little force in moving the pistons, unless the water is drawn from an accumulator that acts by the compression of air, or other elastic fluid.

The difference between employing elastic mediums like air and steam, and an inelastic medium like water for transmitting force in performing irregular duty, has been already alluded to, and forms a very interesting study for a student in mechanics.

The steam cranes of Mr. Morrison that resemble hydraulic cranes, except that steam is employed as the medium for transmitting force, combine all the advantages of hydraulic apparatus, except positive movement and the difficulties about temperatures, and evade the loss of power that occurs in the use of water. The elasticity of the steam is found in practice to offer no obstacle to steady and accurate movement of a load, provided, the mechanism is well constructed, while the loss by radiation is but trifling.

In manufacturing processes the material operated upon has to be continually moved from one place to another to receive successive operations, and this movement may often be either vertically or horizontally as determined, first, by the relative facility with which the

material may be raised vertically, or moved horizontally, and secondly, by the value of the ground and the amount of room that may be available.

In dense cities where a large share of manufacturing is carried on, the value of the ground is so great that its cost becomes a valid reason for constructing high buildings and moving material vertically by hoists, thus gaining surface by floors, instead of spreading the work over the ground; nor is there any disadvantage in high buildings for most kinds of manufacture, including machine fitting even.

Vertical handling, although it consumes more power, as a rule is more convenient and requires less room than horizontal handling, which is sure to interfere more or less with constructive operations. In machine fitting there is generally a wrong estimate placed upon the value of ground floors, which are no doubt indispensable for the heaviest class of work, and for the heaviest tools, but with an ordinary class of work, where the pieces do not exceed two tons in weight, upper floors if strong are quite as convenient, if there is proper machinery for handling material; in fact the records of any establishment, where cost accounts are carefully made up, will show that the expense of fitting on upper floors is less than on ground floors; this is to be accounted for by better light and a removal of the fitting from the influences and interference of other operations that have to be carried upon the ground floors.

For loading and unloading carts and wagons the convenience of the outside sling is well known; it is also a now attested fact that accidents rarely happen with sling hoists, although they appear to be less safe than running platforms or lifts.

As a general rule the most dangerous machinery for handling or raising material is that which pretends to dispense with the care and vigilance of attendants, and the safest machinery, that which enforces such attention.

The conditions that lead to danger in hoisting machinery, is that the force used is opposed to that of gravity, and as the force of gravity is acting continually, it is always ready to take advantage of the least cessation in the opposing force employed to overpower gravity, and thus drag away the weight for which the two forces are contending, and as a weight when under the influence of gravity is moved at an accelerated velocity, if gravity becomes the master, the result is an accident. Acting on every piece of matter in proportion to its weight, must be some force opposing and equal to that of gravity; a piece of

iron lying on the floor is opposed by the floor and held in resistance to gravity, and to move this piece of iron we have to substitute some living force like that of the hands or lifting mechanism to overcome gravity.

In reasoning in this manner about gravity, it may seem to the apprentice as being a troublesome kind of phenomenon that might be dispensed with, but he must remember that we rely upon gravity to keep things in place, and without it nothing would be fixed.

Reasoning further of gravity, we see that it acts only in one direction—vertically—so that the main force of hoisting and handling machinery which opposes gravity, must also act vertically, while the horizontal movement of weights may be accomplished by simply overcoming the friction between the weights and the surfaces on which they rest.

This is seen in practice; a force of a hundred pounds may move a weight upon a truck, that it would require tons to lift vertically; hence the horizontal movement of material may be easily accomplished by hand with trucks and rollers, so long as it is moved on level planes; but if a weight has to be raised even a single inch by reason of irregularity in floors, we at once feel the difference between overcoming frictional contact and opposing gravity.

One of the principle problems connected with the handling of material is to determine where hand-power should stop and motive-power begin; what conditions will justify the erection of cranes, hoists or tramways, and what conditions will not.

Frequent mistakes are made in the application of power when it is not required; and the too common tendency of the present day being to apply power to every purpose where it is possible, without estimating the actual saving that may be effected. A common impression is that motive power, whenever applied to supplant hand labor in handling material, produces a gain; but the fallacy of this in many cases is apparent, when all the conditions are taken into account.

Considered upon grounds of commercial expediency as a question of cost alone, it is generally cheaper to move material by hand when it can be lifted by workmen, when the movement is mainly in a horizontal direction, and when the labor can be constantly employed; or, to assume a general rule, vertical lifting should be done by motive power, and horizontal movement for short distances performed by hand.

There is nothing more unnatural or wasteful of power than for

men to carry loads up stairs or ladders. The effort expended in such cases is one half or more devoted to raising the weight of the body, which force is not utilized in the descent, and it is always better to use winding or other mechanism for raising weights, even when it is done by manual effort.

Speaking of this matter of carrying loads upward, I am reminded of the fact that builders in England and America, especially in the latter country, often have the material carried up ladders, while in some of the older European countries, where there is but little pretension to scientific manipulation, the bricks are tossed from man to man, and mortar raised by pulleys.

To conclude, the reader will understand that the difficulties and diversity of practice, in any branch of engineering, create similar or equal difficulties in explaining or reasoning about the operations, and the most that could be done in the limited space allotted to the subject of moving material here has been to point out some of the principles that should govern the construction and adaptation of handling machinery, from which the apprentice reader can take up the subject upon his own account, and follow it through the various examples that will come under his notice.

To summarize, we have the following propositions in regard to moving and handling material :

1. The most economical and effectual mechanism for handling is that which places the amount of force and rate of movement continually under the control of an operator.
2. That the necessity for, and consequent saving effected by, power-machinery for handling is mainly in vertical lifting, horizontal movement being easily performed by hand.
3. The vertical movement of material, although it consumes more power, is more economical than horizontal handling, because less floor-room and ground surface are required.
4. The value of handling machinery, or the saving it effects, is as the constancy with which it operates; in supplanting hand labor such machinery, may shorten the time of handling without cheapening the expenses.
5. Hydraulic machinery comes nearest to filling the required conditions in handling material, and should be employed in cases where the work is tolerably uniform, and the amount of handling will justify the outlay required for the machinery.
6. Handling material in machine construction is one of the principal

expenses to be dealt with; each time a piece is moved its cost is enhanced, and usually in a much greater degree than is supposed.

7. As the judgment of one man is sufficient to direct handling operations, all the power required in such work, beyond what that one man can exert, should be motive power, if such motive power can be employed for any considerable portion of the time.

8. Power employed in handling material and for other purposes, when it is employed intermittently, must be represented in the motive power, otherwise lifting will interfere with the operation of machines and tools.

MACHINE COMBINATIONS.

The combination of several functions in the same machine, although it may seem an unimportant matter to be considered here, is nevertheless one that has much to do with manufacturing machinery, and constitutes what we may term a principle in construction.

The reasons that favor the combination of several functions in one machine, and the effect that such combination may have on the product of machines, are so various that it has led to a great diversity of opinions and practice among both those who construct and those who employ machines.

It may be said too that a great share of the combinations we see in machines, such as those to turn, mill, and bore, slot and drill in iron fitting, are due not to any deliberate plan on the part of the maker so much as to an opinion that such machines are novel, and represent a double or increased capacity.

So far has this combination in machines been carried, that in one case that came under the writers notice, a machine was arranged to perform nearly every manipulation required in finishing the parts of machinery; completely organized, and displaying a high order of mechanical ability in design and arrangement, but practically of no more value than a single machine tool, because but one operation at a time could be performed.

To direct the attention of the apprentice to certain rules that will guide his opinions and practice in this matter of machine combination, I will present the following propositions and afterwards consider them in detail.

First. By combining two or more operations in one machine the objects gained are economy in framing, the same supports answering double purpose, and a saving of floor room.

Second. In a machine where two or more operations are combined the capacity of such a machine is only as a single one of these operations, unless they can be carried on at the same time without interfering one with the other.

Third. Combination machines can only be used with success when one attendant performs all the operations, and when the change from one operation to another requires but little adjustment and rearrangement in each case.

Fourth. The arrangement of the parts in a combination machine have to be modified by the relations between them, instead of being adapted directly to the nature of the work to be performed.

Fifth. The cost of special adaption and the usual inconvenience of fitting combination machines, when their parts operate independently, generally equals what is saved in framing and floor space.

Referring first to the saving that is effected by combining several operations in one machine, there is perhaps not one constructor in twenty that ever stops to consider what is gained, and perhaps not one purchaser in a hundred that does the same thing. The impression is that when one machine performs two operations it saves a second machine, or several other machines.

A remarkable example of this exists in the manufacture of combination machines for working wood in England, where it is common to find complicated machines that will perform all the operations of a joiner-shop, but as a rule perform one operation at a time, and usually in an inconvenient manner, each operation being hampered and interfered with by another, and in changing from one kind of work to another the adjustments and changes generally equal and sometimes exceed the work to be done. What is stranger still is that such machines are employed when their cost equals that of separate machines to perform the same work.

In metal working, owing to a more perfect division of labor, and a more intelligent manipulation than in wood-working, there is less combination in machines, and is rarely seen at this day, at least in cases where it occasions an actual loss of time or cost.

The advantage of such combinations, as said, can only be in the framing and floor space occupied by the machines, but these considerations, to be estimated by a proper standard, are quite insignificant when compared with other items in the cost of machine operating, such as the attendance, interest on the invested cost of the machine, depreciation of value by wear, repairing and so on.

Assuming that a machine will cost as much as the wages of an attendant for one year, which is not far from an average estimate, for iron working machine tools, and that interest, wear, and repairs amount to ten per cent. on this sum, then the attendance would cost ten times as much as the machine; in other words, the wages paid to a workman to attend a machine is on an average ten times as much as the other expenses attending its operation, if we except power.

This assumed, it follows that in machine tools any improvement directed to labor saving will effect *ten times* as much as an equal improvement directed to the economy of first cost or in reducing the instrument.

The same mode of reasoning will lead to a proper estimate of the difference in value between good tools and inferior tools; the results of performance instead of the investment should be considered first because the expenses of operating are, as before said, usually ten times as great as the interest on the investment in a machine itself.

In view of these propositions I need hardly say to what object machine-improvements should be directed, nor which of the considerations named are most affected by a combination of machine functions; the fact is that if careful statistics could be prepared, showing the precise effect on machine combination, it would astonish many who have not investigated the matter, and in many cases would show a loss of the whole cost of the machines each year.

The effect of combinations in machinery is, however, by no means regular, and the remarks made apply to standard machines employed in the regular work of an engineering or other establishment; in exceptional cases it may be expedient to use combined machines. In the tool room of machine-shops, for instance, where one man can usually perform the main part of the work, and where there is but little space for machines, the conditions are especially favorable to combination machines that may be used in milling, turning, drilling, and so on; but wherever there is a necessity or an opportunity to carry on two or more of these operations at the same time, the cost of separate machines is but a small consideration when compared with the saving of labor that may be effected by independent tools to perform each operation.

The whole tendency of manufacturing processes of every kind, at this day, is to a division of labor, and to separate each operation into as many branches as possible, and study spent in segregating instead of aggregating machine functions is most likely to produce useful results.

I have introduced this article not only to give the learner a true understanding of the effect and value of machine combination, but to caution him against the very common error of confounding machine combination with invention.

A great share of the alleged improvements in machinery when investigated will be found to consist in nothing more than the combination of several functions in one machine, the novelty of their arrangement leading to an impression of utility and increased effect, but when tried by such standards as have been suggested to determine their value, these supposed improvements will generally be found of no use and not unfrequently a positive disadvantage.

(To be continued.)

ON THE MECHANICAL CALCULATION OF EARTHWORK, (or the Results of Physical Measurements in General), ACCORDING TO THE PRISMOIDAL OR OTHER FORMULAE.

BY CLEMENS HERSCHELL, C. E.

The polar planimeter is an instrument that will, mechanically, find the value of A in the general equation,

$$A = \int F(x) dx.$$

It will also, by repeated and consecutive operations, find the value of A , in

$$A = \sum \int F(x) dx.$$

Finally, by changing the length of the tracing arm, it can be made to find the value of A in the equation

$$A = C \sum \int F(x) dx,$$

where C is any constant.

In ordinary language this means, it will add up the areas multiplied by any constant, of any number of any shaped plane surfaces, and reflection will show how these properties render it capable of solving mechanically many questions, the solution of which would otherwise be very complex. Indeed, it is probable that the full uses of this and other kindred instruments* are yet to be discovered, and that

* A modification of the polar planimeter has been invented that will find the centre of gravity of any figure, its moment of inertia about any line, etc., or generally will solve the equation

$$A = \int F(x)^2 dx$$

they are destined to be the aids not only of the civil and mechanical engineer, but of all experimenters, who use the exact sciences, in their own peculiar class of investigations.

As an example of what the instrument is capable of, its practical application in the calculation of earthwork, according to the prismoidal formula, will be described.

Written in the form of a series, the prismoidal formula becomes

$$\text{Contents} = \frac{H}{3} (S_0 + 4S_1 + 2S_2 + 4S_3 + 2S_4 + \dots + S_n)$$

where H = the uniform distance from cross-section to cross-section, $S_0, S_1 \dots S_n$ are the areas of the cross and end sections, and n must equal an even number.

For earthwork H is usually 100 ft. If the cross-sections are given in square feet, and the answer is desired in cubic yards, the formula becomes, with a few changes,

$$\begin{aligned} \text{Contents in cubic yds.} = & \frac{2 \times 100}{3 \times 27} \left[S_0 + S_1 + S_1 + S_2 + S_3 + S_3 \right. \\ & \left. + S_4 + \dots + S_n - \frac{S_0 + S_n}{2} \right]. \end{aligned}$$

This brings the formula into the general shape given above,

$$A = C \sum \text{areas},$$

which can be read directly by the planimeter. There remains to be introduced, however, one more constant, namely, the one having reference to the scale in which the cross-sections are submitted for measurement. If this, as is usual on cross-section paper, is 8 ft. = 1 inch, the planimeter, to give A , as above, in cubic yards, will have to read $\frac{2 \times 100 \times 64}{3 \times 27}$ per square inch of paper circumscribed, or, since the circumscribed area is equal to the length of the tracing arm* multiplied by the distance rolled by the wheel, the appropriate length of this arm, to read as above desired, is easily found. Should this length be inconvenient in the manipulation of the planimeter, take, say its double, if that be better, which will result in the final answer being just one-half the true one. If, as the instrument then reads, H , however is taken equal to 50 ft. the final answer will be the true one; if H be equal to 10 ft. it will represent five times the true answer, and so on. These last points become of value in prac-

* See, amongst others, Rankine's Civil Engineering. p. 33.

tice in the mechanical calculation of cuts and fills, working from ordinary railroad profiles, as will presently appear. In such cases the operation would be about as follows :

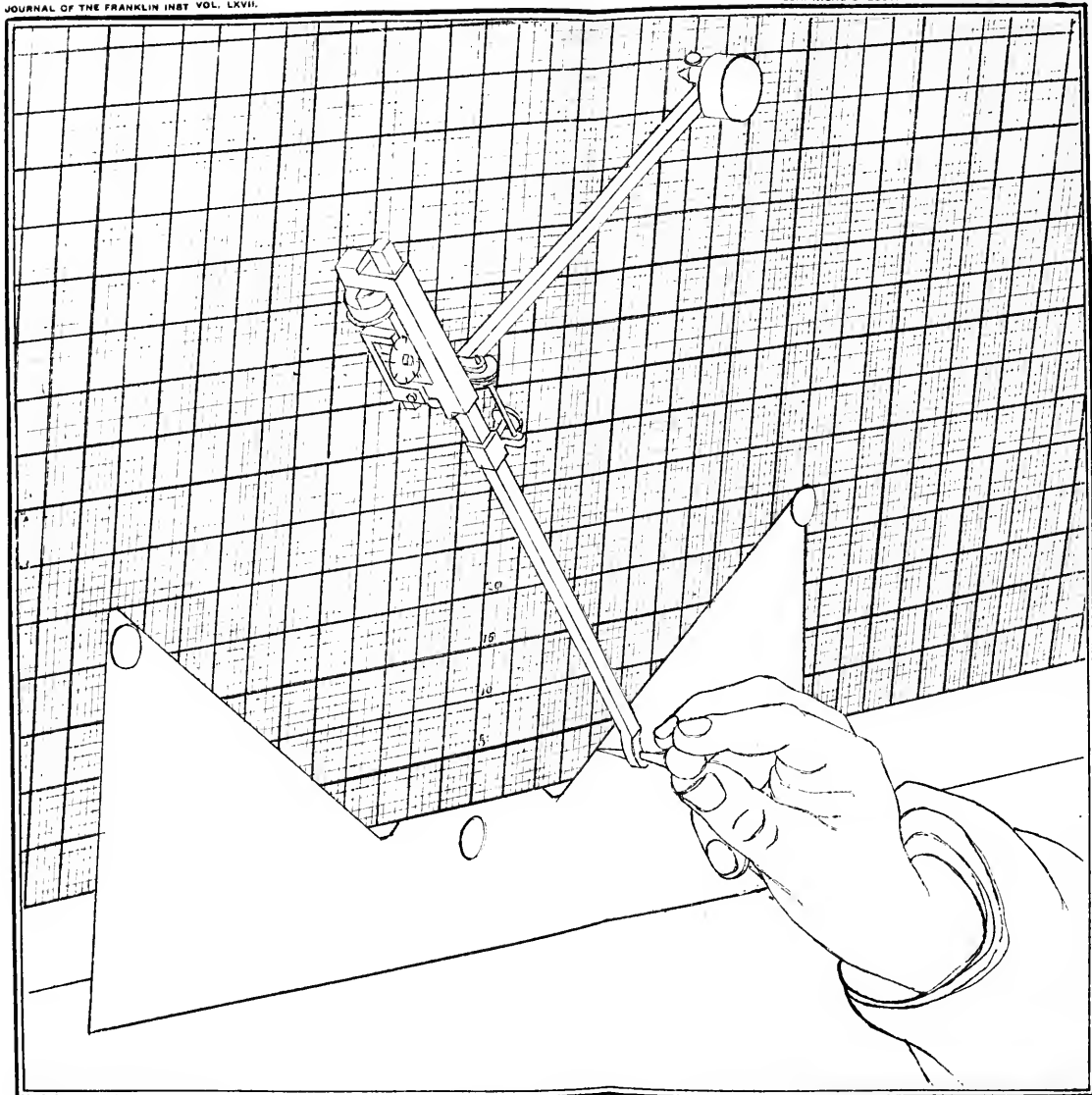
Take a sheet of ordinary cross-section paper, ruled with $\frac{1}{8}$ inch squares ;† mark one line of it as the grade line of the cross-sections to be measured.

Figure the centre line heights on the sheet. Next, in the edge of a piece of stiff paper, cut out, to a scale of $\frac{1}{8}'' = 1$ ft., the cross-section of a cut and of a fill for the maximum centre or side height that is likely to occur. Laying this down on the ruled sheet with the two grade lines covering one another, we are ready to commence operations. Take a reading of the instrument. An assistant reads off such data as may be in the note book about S_0 . Whatever they are, they can be readily taken into account, in moving the tracing arm of the planimeter around a figure representing this cross-section. The pattern is a guide for the tracing point on three sides of the cross-section, the top is read directly on the ruled and numbered sheet beneath, either for centre heights alone, or for side heights in addition, slopes of surface or any other data that may be given. After moving the tracing point around S_0 take another reading. The difference between these two readings gives S_0 multiplied by the constant, which is to be noted, as $\frac{S_0 + S_n}{2}$ multiplied by the constant must be sub-

tracted at the end, according to the formula above written. The assistant next calls off the data for S_1 , and that is circumscribed, next S_2 , S_3 , etc., the instrument doing its own addition. Take a reading after going around S_{n-1} , and again after circumscribing S_n , so as to get the value of S_n for use in $\frac{S_0 + S_n}{2}$. After going through all the sections in this manner keep the crank moving around all the odd S 's, (S_1 , S_3 , S_5 etc.) again. The difference between the first and final readings, minus $\frac{S_0 + S_n}{2}$ found above, is, for $H = 100$ ft., just half

the contents of the cut or fill in cubic yards, with a probable error, which, at present, we find need not be greater than two yards in a thousand, or 0.2 of 1 per cent.

† If the paper has shrunk so that 64 squares do not measure exactly one square inch, but say only .9 of a square inch, the result obtained from such a sheet must be increased $\frac{1}{9}$, and so on. Or, rule a sheet into squares of exactly $\frac{1}{8}$ square inch and work from that.





As railroad and other profiles occur in nature, and because n must be an even number, there will usually be some odd pieces left at each end in passing from cuts to fills and *vice versa*. These are most accurately disposed of by imagining them cut up into 10, 20, $33\frac{1}{3}$ ft., or any other even division of 100 feet lengths, then measuring them exactly by the same process as just described, then the answer given by the instrument will be to the true answer as the standard H is to the temporarily assumed H .

It might be argued that this method will still leave some small chips at the ends, but they are evidently of so small moment that they may be neglected. If desired, however, there is, of course, nothing to prevent the sections being taken even every foot in length. Other less exact methods of calculating the end pieces, yet without giving up the advantages derived from the use of the planimeter, are easily devised.

The mechanical method of calculating earthwork, above described, is equal in accuracy to that of the usual operations in the field; it will give results more or less approaching the exact truth, as the latter give more or less data to work from. It is safe to say that no tables yet devised will do anything of the kind for all cross-sections, and when we compare the amount of labor involved in the two methods the contrast is still more glaring. Probably no one who has once tried the planimeter method will again consider the calculation of long lines of earthwork from tables or formulæ as anything else but a species of slavery; for short pieces, though the advantages derived from the former are proportionally less, they are notwithstanding quite as decided. From the few experiments tried in my office I estimate the saving of time derived from the use of the planimeter, over that required by calculating from tables or from formulæ, as $\frac{1}{2}$ to $\frac{1}{5}$, according as the cross-sections or note-book data are found tabulated more or less perfectly; the saving in labor is still greater and the gain in accuracy is nevertheless marked and valuable. The degree of accuracy practically attained surpasses what in any ordinary work has hitherto been considered practically attainable.

It would have been just as easy to have made the instrument read cubic yards of contents, according to average end areas, but as the prismoidal formula is much the most accurate, and as one formula, when incorporated in the machine involves no more labor than the other, we, of course, prefer the most accurate. The average-end area formula, as a series, would read:

$$\text{Contents in cub. yds.} = \frac{100}{27} \left[S_0 + S_1 + S_2 + S_3 + \dots S_n - \frac{S_0 + S_n}{2} \right]$$

and the proper length of tracing arm can be deduced as before.

These examples will be sufficient to show the wide application that the polar planimeter is probably yet capable of. Such, for example, would be its use as a counter, that will indicate the total horse-power delivered by a steam engine during any period of time, or in friction brake trials, in short for giving the results of a multitude of experiments in civil and mechanical engineering, in acoustics, electricity, and other investigations, say wherever the final result is dependent on any two variables and one or more constants.

Boston, Feb. 21, 1874.

A Lecture Experiment with Potassium.—Mr. H. Kaemmerer communicates the following item to the German Chemical Society, upon a more practical and satisfactory method of showing, experimentally, the green color of potassium vapor. The experiment is generally performed by simply heating a fragment of the metal in a test-tube. In this manner, however, the color of the vapor is only visible for a few seconds, and not at all satisfactorily, inasmuch as its oxidation transpires almost instantly after its formation.

The experiment may be made much finer and upon a larger scale, if the potassium is vaporized in a tube of about a foot in length, placed horizontally, and through which a stream of hydrogen gas is passed during its continuance. Conducted in this way, the experiment is far superior to that first named. The wide tube is speedily filled with the beautiful green vapor of the metal, which deposits itself upon the cool portions of the tube as a lustrous metallic mirror, while the hydrogen escaping from the opposite end (the tube having been drawn out to a narrow opening for the purpose), may be inflamed, and burns with a rich violet light, giving off at the same time thick clouds, from the formation of potassa.

Chemistry, Physics, Technology, etc.

ON THE THERMAL AND MECHANICAL PROPERTIES OF AIR AND OTHER PERMANENT GAS, SUBJECTED TO COMPRESSION OR EXPANSION.

BY PROFESSOR R. H. THURSTON.

[REMARK :—Several months ago, a correspondent of the *American Artisan* requested the editor of that periodical to publish a table of pressures and of temperatures due to compression of air up to one-hundred pounds per square inch. The writer was applied to, by the publishers, and soon after supplied such a table in which temperatures, volumes and pressures were given for each five pounds from vacuum up to two hundred pounds per square inch.*

Subsequently a graphical representation of these tables was carefully constructed by a pupil, and very skilfully lithographed, by the American Industrial Publishing Company of New York, for use in the course of instruction at the Stevens Institute of Technology. A reduced copy of these curves was published still later.†

The interest taken by members of the profession and particularly by those engaged in the study of the applications of compressed air and in the development of the hot air engine, and also the investigation of the writer, and his interest in the labors of his colleague, Professor Wood, in the attempt to perfect a new form of rock drill, have induced a more complete examination of the subject; and the preparation of the table here presented, which is probably sufficiently complete to meet all the requirements of engineering practice, and may not require further extension for many years.

The accompanying is a part of a paper prepared in the course of instruction of the engineering classes of the Stevens Institute of Technology, supplementing the instruction obtained from their text books.]

1. When air and other gases are compressed by the application of external force, the mechanical energy, or work done in its compression, takes effect in two ways:—

**American Artisan*. March 8th. 1873; page 150.

†*Ibid* March. 1874.

First, The rate of motion of the particles composing the mass is increased.

Secondly, The relative distances of the particles is diminished.

The first effect becomes evidently an augmentation of temperature, the second, by an increased tension.

By expansion, the potential energy resulting from these two forms of force becomes re-transformed into mechanical work.

2. There are many industrial applications of the phenomena here noted.

The storing of power in compressed air is frequently made essential in mining and tunnelling operations, in which it would be impossible to use steam as a motor for driving engines or working rock drills.

In hot air engines, the increase of tension due to increased temperature, becomes useful in the derivation of mechanical power from thermal action.

In cooling air for ventilating purposes, and frequently in ice-making, the reduction of temperature by the expansion of previously highly compressed air, these thermo-mechanical relations become important.

3. The great and continually increasing importance of these industrial applications, has made the determination of the law of variation of pressure and volume with change of temperature, a matter of great interest to members of the engineering profession as well as to science.

In compressing air for use in mines or in supplying hot air engines, and in ice making and ventilating, also, the heat of compression increasing the tension of the compressed gas, produces a serious addition to the resistance encountered, and since this heat is always partially, and frequently wholly, dissipated without producing useful effect, the consequent loss of efficiency is correspondingly serious.

In compressed air motors, it becomes often more than one-half; and a hundred horse-power expended in driving the compressor, may, when working at great pressures, yield but fifty horse-power, or even twenty-five, of actual useful work.

It is, in such cases, very important to be able to determine the temperature due to the proposed compression in order to estimate the probable amount of this loss.

In the working cylinder of the hot air engine, the communication of heat to the expanding gas produces a tension which should be estimated when the engine is designed, in order to determine the limits both of pressure and temperature, allowable or advisable.

4. Two cases form the limits between which are comprehended all actual examples of change of volume and pressure.

The first case is that in which the temperature of the mass is kept invariable by removing completely the heat of compression or by communication of heat during expansion, as rapidly as becomes necessary to supply that transformed into other forms of energy.

The second case is that in which the change of state, as to pressure and volume, occurs in a perfectly non-conducting chamber, and, consequently, a change of temperature and a modification of the rate of variation of tension noted in the first case may occur.

In all examples met with in the practical work of engineering, the method of variation lies between these limiting cases.

If it be desired to retain the quantity of heat present without change, it is always found impossible to obtain any form of apparatus which is impervious to heat and which will absolutely prevent a flow of heat into, or out of, the air reservoir.

The air also contains, invariably, a considerable amount of the vapor of water which, having a comparatively great capacity for heat, will produce a marked alteration of temperatures as observed with dry air.

If it be desired to absorb the heat of compression, and to keep the temperature of the mass perfectly invariable, as in the first of the two representative cases, it will always be found impossible to obtain a perfectly efficient method of securing a sufficiently rapid outflow of heat from the gas undergoing compression, both because of the impossibility of finding a perfect conductor of heat and of the fact that air and other gases are exceedingly imperfect transfers of heat, being apparently absolute non-conductors.

All actual cases, therefore, are intermediate between the two here considered, and only experience and a trained judgment can be relied upon to estimate the true conditions in any individual example.

5. CASE 1ST, is that to which that law applies which was discovered independently by the English philosopher Boyle and the French savan Marriotte, viz: "*The temperature remaining the same, the volume of a given quantity of gas is inversely as the pressure.*"

Assuming one hundred volumes of air, originally of mean atmospheric pressure, 14.7 pounds per square inch, to undergo change of pressure and volume, the relation of pressure and volume is expressed by the equation, $PV=P^1V^1$; and, for this case, $PV=1470$, hence

$$V = \frac{1470}{P} \quad (1)$$

where P^1 and P are the pressure in pounds per square inch above a vacuum, and where V^1 and V are the volumes.

Regnault, who made the most elaborate and accurate research in this direction, found that the permanent gases followed this law very closely, although not precisely, while the liquefiable gases departed from it more considerably.

The permanent gases, including air, deviate so slightly from the law that Dulong and Arago, who compressed air to 27 atmospheres pressure, were unable to detect the deviation afterwards discovered by Regnault.

For all ordinary cases of application the law may be assumed exact, and it is so assumed in the table here given.

6. CASE 2D,—or that in which a change of volume, pressure and temperature occurs without transmission of heat into, or out from, the mass,—requires, for its complete examination, a determination of the specific heat of the gas, both under constant pressure and constant volume, and of its co-efficient of expansion, and a knowledge of the mechanical equivalent of heat.

The specific heat of air was determined by De la Roche and Berard, by De la Rive and Marcet, and finally, with greatest probable accuracy, by Regnault. It has the value, under constant pressure, of 0.2379, water being taken as the standard, and its specific heat being 1.

The specific heat of a gas under constant volume has not been determined by direct means, but, by an indirect determination based on the acceleration of the velocity of sound due to changes of temperature produced by alternate expansion and contraction, it has been found to have a ratio to specific heat under constant pressure of 1.408 to 1.

The co-efficient of expansion of air, as determined by Regnault, is found to be .003665 for the centigrade scale or .002036 for Fahrenheit degrees.

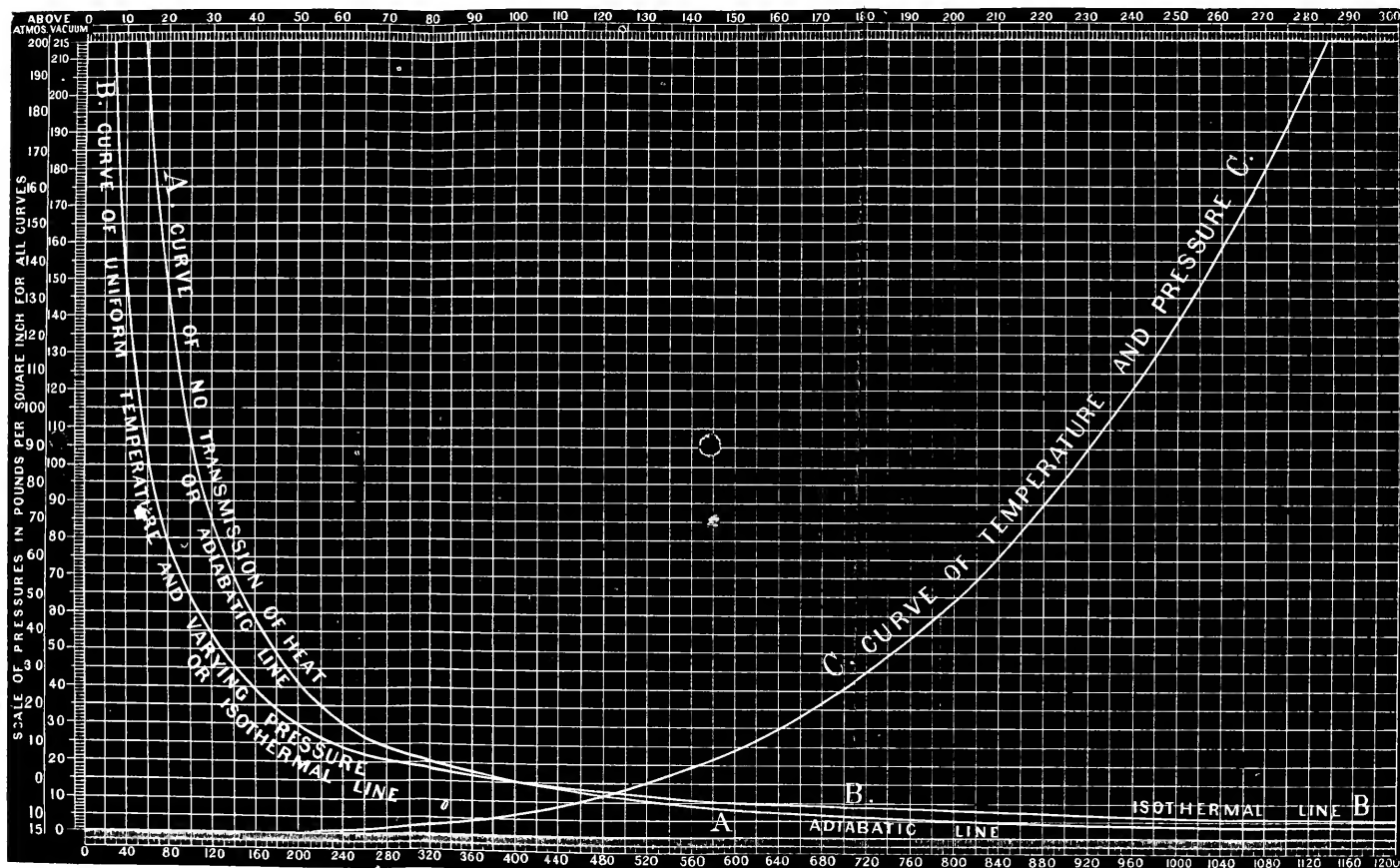
The specific heat of air seemed to be constant for all pressures. The co-efficient of expansion varies slightly, but not sufficiently to make it necessary to consider that variation in this paper.

The data for calculating the mechanical equivalent of heat were first given approximately by Rumford in 1798, in the paper* in which

* Phil. Trans. Royal Soc. 1798: also, Trans. Am. Society of Civil Engineers, 1873. Art. 67.

Graphical Representation of the Thermal and Mechanical Properties of Air and Permanent Gases, by Professor Thurston.

SCALE OF VOLUME FOR CURVES A A AND B B.



ABSOLUTE SCALE OF TEMPERATURES FOR CURVE C C, IN FAHRENHEIT DEGREES. DEDUCT 461.2 FOR COMMON SCALE.

The pressure being given, to determine the coincident volume, when the mass consisted originally of 100 volumes at atmospheric temperature and density:—

Follow a line parallel with the base line, from its intersection with the given pressure on the scale, to its intersection with the adiabatic, or curve of no transmission of heat, for ordinary cases, or, with the isothermal line when the temperature of the air remains perfectly uniform: thence follow a vertical line upward to the scale where the required volumes can be read off.

The reverse of this operation gives the change of pressure, the alterations of volume being known.

To find the temperature due a given degree of compression: Find coincident readings on the scale of temperature and pressure for the proper point on the curve, C.



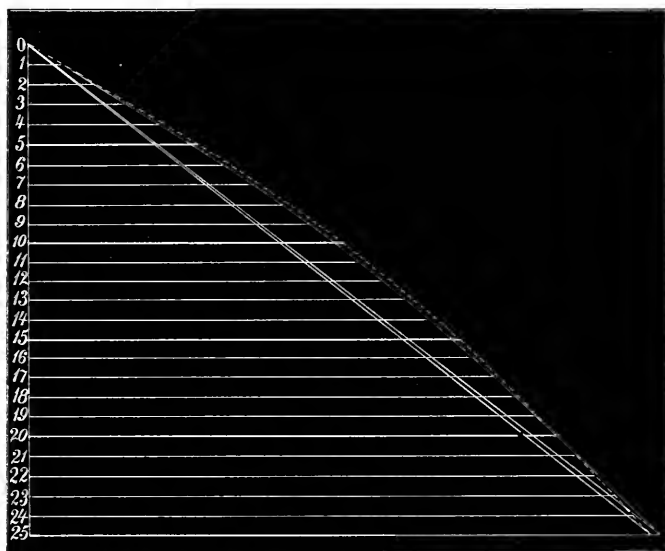
he announced the now well-known fact that heat and mechanical

Jour. Frank. Inst. Vol. LXVII.

Mech. and Thermal Prop. of Air, Plate II.

**Curves exhibiting the agreement of the experimental determination
of Capt. Ericsson with the estimates of R. H. Thurston.**

PREPARED BY CAPT. JOHN ERICSSON, NEW YORK, 1874.



Ordinates of dotted line represent increments of temperature by compression above the atmosphere, as ascertained by Ericsson.

Ordinates of continuous line represent temperature estimates by Thurston.

Marginal figures represent tension of compressed air in pounds per square inch above atmosphere.

* See TAIT; *Sketch of Thermodynamics*. London, 1868.

† *Steam Engines and Prime Movers*.



he announced the now well-known fact that heat and mechanical energy are simply two methods of manifestation of force, and are mutually convertible. Mayer and Joule, in 1842 and 1843, independently determined it, and the experimental investigations of the latter are now relied upon as giving very accurately its value. The accepted value is 772 foot pounds as the equivalent of the British thermal unit, and 1389.6 foot pounds for the French *caloric*.

Clausius, Rankine, Thompson and Zeuner have based upon these experimental determinations a branch of this science of energetics, which is known as "Thermodynamics." The first two named, independently constructed the general equation of thermodynamics, which is an algebraic expression of the mutual relations of thermal and mechanical energy, and embodies the fundamental principles of the science.*

The equations representing the relations of pressure, temperature and volume of air and the permanent gases, as deduced by these authorities, and as given by Rankine,† is

$$\frac{\tau}{\tau_1} = \left(\frac{v_1}{v_2}\right)^{\gamma-1} = \left(\frac{p_2}{p_1}\right)^{\frac{\gamma-1}{\gamma}} \quad (2)$$

in which $\tau_1, \tau_2, v_1, v_2, p_1, p_2$, are the absolute temperatures, the volumes and the pressures of the gas, and γ represents the ratio of the specific heat of constant pressure to the specific heat of constant volume. The latter ratio is that of the energy required to change the state of the gas as to temperature merely to that required to effect both a change of temperature and of intrinsic energy.

From (2) we obtain

$$p \approx \frac{1}{v^\gamma} \quad (3)$$

The values of the several exponents for air are $\gamma = 1.408$, $\gamma-1 = 0.408$ and $\frac{\gamma-1}{\gamma} = 0.29$, as given by Rankine, and deduced from Regnault, Magnus and Rudberg.

From these equations, and equation 1 previously given, the values given in the following table are obtained. They are determined for a wider range than will probably be required in any engineering estimates.

* See TAIT; *Sketch of Thermodynamics*. London, 1868.

† *Steam Engines and Prime Movers*.

8. The graphical representation of Case 1st, which case is given numerically in column C of the table, is an "isothermal line."

The curve representing the relative values of pressure and volume under Case 2d is an "adiabatic line."

These two lines, as well as the graphic representation of the changes of pressure and temperature, are seen in the accompanying large plate as they were beautifully reduced for the *American Artisan*.

The curves here given exhibit to the eye the very considerable difference in pressures resulting from similar changes of volume in the two representative cases, and illustrate well the fact that, in the use of compressed air for transmission of power, the loss of efficiency must be very serious, when, as is almost invariably the case, the heat of compression is not removed as produced.

At low pressures even, the losses of heat, or by its removal by special provisions, are exceedingly small, as is shown by the accompanying pair of curves (Plate II), prepared for the writer, by Captain Ericsson, to illustrate the close correspondence between the pressures and temperatures noted by him during his experiments, extending, as he states, over a series of years, and the estimates here presented.

At five pounds above the atmosphere, the difference is given as $\frac{1}{1.57}$, at ten pounds $\frac{1}{3.7}$, at fifteen pounds $\frac{1}{9.6}$, at twenty pounds the figures coincide perfectly, and at twenty-five pounds the discrepancy is $\frac{1}{88}$.

The experimenter, in the letter accompanying this comparative statement, says :

"In view of the loss of heat by radiation, the close agreement between theory and practice will surprise those who do not consider that, during the first portion of the stroke of the piston, the confined air, before attaining maximum tension, receives much heat from the cylinder.

"Indeed, but for the fact that the heating of the air, and consequent expansion while being drawn into the cylinder, prevents a full supply of air of atmospheric density, this increment of pressure attained in practice would greatly exceed the theoretical determination."

Professor Frazier has made a mathematical investigation of the amount of energy expended in compressing air and working the compressed fluid,* and gives the following :

*Engineering and Mining Journal, July, 1873.

TABLE SHOWING PROPORTION OF WORK LOST.

Absolute working pressure in atmospheres.	I With full expansion.		With no expansion.	
	Air completely cooled in compressor.	Air not cooled in compressor.	Air completely cooled in compressor.	Air not cooled in compressor.
2	0.09	0.18	0.28	0.35
3	0.14	0.27	0.39	0.48
4	0.18	0.33	0.46	0.56
5	0.20	0.37	0.50	0.61
6	0.22	0.40	0.53	0.65
7	0.24	0.43	0.56	0.67
8	0.25	0.45	0.58	0.69
9	0.26	0.47	0.60	0.71
10	0.27	0.49	0.61	0.73

The importance of removing the heat of compression as completely as possible, and simultaneously with its production, is here well shown, as well as by the table and diagrams above given. Were it possible to retain completely this transformed energy, the economical result would evidently be still more satisfactory, however, and the devising of efficient means of utilizing these two methods of avoiding a now serious loss, in all cases of air compression, is a very important engineering problem.

Stevens Institute of Technology, Hoboken, N. J., Feb., 1874.

ON THE STRENGTH, ELASTICITY, DUCTILITY AND RESILIENCE OF MATERIALS OF MACHINE CONSTRUCTION,

And on Various Hitherto Unobserved Phenomena, Noticed during Experimental Researches with a New Testing Machine, fitted with an Autographic Registry.

BY PROF. R. H. THURSTON.

Read before American Society of Civil Engineers, Feb. 4, 1874.

SECTION I.

1. INTRODUCTORY.*—Some months ago, while engaged with the advanced classes of the Stevens Institute of Technology, in experimental investigations of the resistance of materials, it was found that coefficients were given, by various authorities, which neither accorded fully with each other or with those then obtained.

The desirability of determining how far these differences were due to errors of observation, and how far to variation in the quality of the materials examined, induced the writer to design several machines for the purpose of conducting with them a more extended and exact

* *Vide* Journal Franklin Institute.

series of experiments. The machine for measuring torsional resistance was furnished with an automatic registry, recording a diagram which is a reliable and exact representation of all circumstances attending the distortion and fracture of the specimen. No system of personal observation could probably be devised which could yield results either as reliable or as precise as such a system of autographic registry, and, as no method previously in use had given simultaneously, and at every instant during the test, the intensity of the distorting force and the magnitude of the coincident distortion, it was anticipated that the new method of investigation might be fruitful of new and, possibly, important results. This expectation, as will be seen, has been more than realized.

2. DESCRIPTION OF THE APPARATUS.

—The machine, as planned by the writer, and as built in the instrument makers' workshop, at the Stevens' Institute, is shown in Fig. 1. This form is that with which the investigations to be described were made. Since its construction, in 1872, however, some changes and improvements have been made in the design to adapt it to general work, and new designs have been made for special kinds of work, as for wire mills, railroad shops and bridge building.

Two strong wrenches, C E, B D, are carried by the frames A A, A' A', and depend from axes which are both in the same line, but are not connected with each other. The arm, B, of one of these wrenches carries a weight, D, at its lower end. The other arm, C, is designed to be moved by hand, in the smaller machines, and by a gear and pinion, or a worm gear in larger forms of the apparatus. The heads of the wrenches are made as shown in Fig. 2, the recess, M, being fitted to take the head, on the end of the test pieces, which is usually given the form shown in Fig. 4.

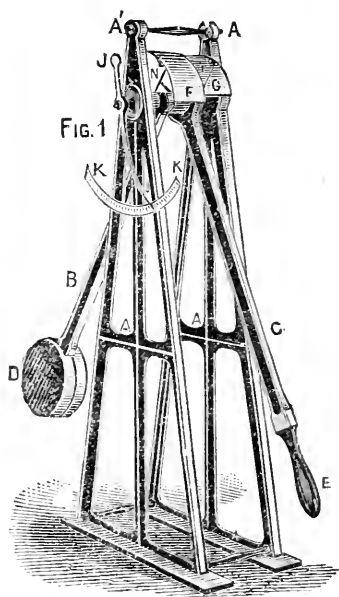


FIG. 2

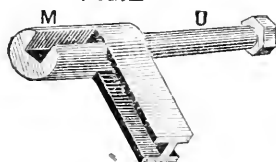
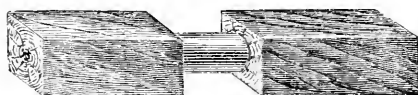


FIG. 3



FIG. 4



A guide curve, F, of such form that its ordinates are precisely proportional to the torsional moments exerted by the weighted arm, B D, while moving up an arc, to which the corresponding abscissas of the curve are proportional, is secured to the frame A A¹. The pencil holder, J, is carried on this arm, B D, and as the latter is forced out of the vertical position, the pencil is pushed forward by the guide curve, its movement being thus made proportionate to the force which, transmitted through the test piece, produces deflection of the weighted arm. This guide line is a curve of sines. The other arm, C E, carries the cylinder, G, upon which the paper receiving the record is clamped, and the pencil, J, makes its mark on the table thus provided. This table having a motion, relatively to the pencil, which is precisely the angular relative motion of the two extremities of the tested specimen, the curve described upon the paper is always of such form that the ordinate of any point measures the amount of the distorting force at a certain instant, while its abscissa measures the distortion produced at the same instant. The maximum hand, J, is sometimes useful as a check upon the record of maximum resistance.

The convenience of operation, the small cost,* and the portability of the machine are hardly less important to the engineer than the accuracy, and the extraordinary extent of information obtainable by it.

3. METHOD OF OPERATION.—The test piece having been given the shape and size which are found best suited for the purpose of the experiment, and to the capacity of the machine, it is placed in the jaws of the two wrenches, each of which takes one of its squared ends, and, a force being applied to the handle, E, the strain thrown upon the specimen is transmitted through it to the weighted arm, B D, causing it to swing about its axis until the weight exerts a moment of resistance which equilibrates the applied force. As the magnitude of the distorting force changes, the position of the weight simultaneously changes, and the pencil indicates, at each instant, the value of the stress upon the test piece. As the piece yields under

* Machines of the size of that used in these experiments, but of improved design, are made at the Stevens Institute, at prices as low as \$150.

strains of increasing amount, also, the pencil is carried in the direction of the circumference of the cylinder on which its record is made, and to a distance which is proportional to the amount of distortion, *i. e.*, to the "total angle of torsion." As the applied force increases, the specimen yields, and finally, rupture occurring, the pencil returns to the base line, at a distance from the starting point which measures the angle through which the test piece yielded before its fracture became complete.

4. INTERPRETATION OF THE DIAGRAMS.—It has been shown that the vertical scale of the diagrams produced is a scale of torsional moments, and that the horizontal scale is one of total angles of torsion. Since the resistance to shearing, in a homogeneous material, varies with the resistance to longitudinal stress, it follows that the vertical scale is also, for such materials, a scale of direct resistance, and that, with approximately homogeneous substances, this scale is approximately accurate, where, as here, all specimens compared are of the same dimensions. Since the elasticity of the material is measured by the ratio of the distorting force, to the degree of temporary distortion produced, the diagrams obtained will exhibit the elastic properties of the material, as well as measure its ductility and its resilience.

Referring to the diagrams shown in the accompanying plates, it will be noticed that the first portion of the line is a curve of small radius, convex toward the axis of abscissas, and that the line then rises at a slight inclination from the vertical, but becoming very nearly straight, until, at a point some distance above the origin, it takes a reversed curvature. The first portion of the line is probably formed by the yielding of the loosely fitted packing pieces securing the heads of the specimen, and, after they have taken a bearing, by the early yielding, in some materials, of particles already overstrained. When a firm hold is obtained, the line becomes sometimes nearly straight, and the amount of distortion is seen to be approximately proportional to the distorting force, illustrating "Hooke's law," *Ut tensis sic vis*.

After a degree of distortion which is determined by the specific character of each piece, the line becomes curved, the change of form having a rate of increase which varies more rapidly than the applied force. When this change commences, it seems probable that the molecules, which, up to that point, retain generally their original distribution, while varying their relative distances, begin to change their positions with respect to each other, moving upon each other in a

manner similar, probably, to that action described by Mon. Tresca, and called the "Flow of Solids,"* and to which attention has already been called by Prof. J. Thompson.†

It is this point, at which the line commences to become concave toward the base, that is considered to mark the "limit of elasticity." It will be noticed that it is well defined in experiments upon woods, is less marked, but still well defined in the "fibrous" irons and the less homogeneous specimens of other metals, and becomes quite indeterminable with the most homogeneous materials, as with the best qualities of well worked cast-steel. This point does not indicate the first "set," since, as will be hereafter seen, a set is found to occur, either temporary or permanent, and usually partly temporary and partly permanent, with every degree of distortion, however small. It is at this "elastic limit" that the set begins to become considerable in amount and almost wholly permanent.

The inclination of the straight portion of the line from the vertical measures the *stiffness* of the specimen, the quantity $\text{Cot. } \theta = \frac{1}{\tan. \theta}$ being the ratio of the distorting force to the amount of distortion up to the "limit of elasticity." As it would seem from the results of experiment, as well as of deduction, that this rigidity is very closely, if not precisely, proportional to the hardness, in homogeneous substances, this quantity $\text{Cot. } \theta$ may be taken, for practical purposes, as a measure of the hardness of the metals, as well as of their elastic resistance to compression.

After passing the elastic limit, the line becomes more and more nearly parallel to the base line, and then, with the woods invariably, and in some cases with the metals, begins to fall rapidly before fracture becomes evident in the specimen. Where the rising portion of the line turns and becomes nearly parallel with the axis of abscissas, the viscosity of the material is such that the outer particles "flow" upon those within, and, while themselves still offering maximum resistance, permit molecules nearer the axis to also resist with approximately maximum force. It seems probable that, with the more ductile substances, nearly all are brought up to a maximum in resistance before fracture occurs, and this circumstance will be seen hereafter to have an important influence in determining the resistance to rupture. The hardest and most brittle materials break, with a snap,

* L'Ecoulement des Corps Solides; Paris, 1869, 1871.

† Cambridge and Dublin Mathematical Journal, Vol. III, 1848, pp. 252—266

before any such flow becomes perceivable, and before the line of the diagram commences to deviate, in the slightest degree, from the direction taken at the beginning, and before the approach to the elastic limit is indicated. It is evident that the standard formulas for torsional, as well as for other forms of resistance, cannot be perfectly correct, since they do not exhibit this difference in the character of the resistance offered by ductile and by rigid materials.

The *elasticity* of the material is determined by relaxing the distorting force, at intervals, and allowing the specimen to relieve itself from distortion so far as its elasticity will permit. In such cases, the pencil will be found to have traced a line resembling, in its general form and position, in respect to the coördinates, that forming the initial portion of the diagram, but almost absolutely straight, and more nearly vertical. The degree of inclination of this line indicated the elasticity, precisely as the initial straight line was made to give a measure of the original stiffness of the test piece, the cotangent of the angle made with the vertical, $\text{Cot. } \phi = \frac{1}{T_{un.} \phi}$ being the ratio of the force required to spring the piece through the range recoverable by elasticity, to the magnitude of that range. The fact, to be shown, that this value is always greater than $\text{Cot. } \theta$, for the same metal is evidence that more or less permanent set will always occur, and that the original stiffness of the specimen is always modified, whatever the magnitude of the applied force. The form of the line of elastic change indicates also the character of the molecular action producing it.

Finally, the form of the curve after passing the maximum, or after passing the point at which fracture commences, exhibits the method of variation of strength during the process of fracture. This portion is very difficult to obtain, with even approximate accuracy, with any but the toughest and most ductile materials. This terminal portion of the diagram would be, theoretically, a cubic parabola, the loss of resisting power varying with the progressive rupture of concentric layers, and the remaining unbroken cylindrical portion becoming smaller and smaller until resistance vanishes with the fracture of the axial line. In some cases, the curves obtained from ductile metals exhibit this parabolic line very distinctly. In all hard materials, the jar produced by the sudden rupture of surface particles is sufficient to separate those within, and the terminal line is straight and vertical.

The *homogeneity* of the material tested is frequently hardly less important than its strength, and it is very desirable to obtain evidence which may enable the experimenter to determine the value of tests of samples as indicative of the character of the lot from which the specimens may have been taken. If the specimens are found to be perfectly homogeneous, it may be assumed with confidence that they represent accurately the whole lot. If the samples are irregular in structure and in strength, no reliable judgment of the value of the lot can be based upon their character, and there can be no assurance that, among the pieces accepted, there may not be untrustworthy material which may possibly be placed just where it is most important to have the best. It is evident that the more homogeneous a material, the more regularly would changes in its resistance take place, and the smoother and more symmetrical would be the diagram. The depression of the line immediately after passing the elastic limit exhibits the greater or less homogeneousness of the material. The fact is illustrated in a striking manner in some of the curves presented, and we thus have—what had never, I believe, been before found—this method of determining homogeneousness.

The *resilience* of the specimen is measured by the area included within its curve, this being the product of the mean force exerted into the distance through which it acts in producing rupture, *i. e.*, it is proportional to the work done by the test piece in resisting fracture, and represents the value of the material for resisting shock. The area taken within the ordinate of the limit of elasticity, measures the capacity for resisting shock without serious distortion or injurious set.

The *ductility* of the specimen is deduced from the value of the total angle of torsion, and the measure is the elongation of a line of surface particles, originally parallel to the axis, which line assumes a helical form as the test piece yields, and finally parts at or near the point where the maximum resistance is formed. Its value is given on Plates II and III for each ten degrees of arc. Since, in this case, there is no appreciable reduction of section, or change of form, in the specimen, this value of elongation is our actual measure of the maximum ductility of the material, and is an even more accurate indication than the area of fractured cross section as usually measured after rupture by tension. It is to be understood that wherever comparisons are here made, without the express statement of other conditions, that specimens of the same dimensions are always represented in the diagrams.

5. DESCRIPTION OF ILLUSTRATED DIAGRAMS. THE WOODS.*—Plates I and II exhibit sets of curves which illustrate the general characteristics of a large number of materials, the first showing the peculiarities noted during experiments on the woods, and the second giving an interesting comparison of the metals.

The woods experimented upon were the following, the numbers of the respective curves on Plate I, indicating the material here correspondingly marked :

1. White pine (*Pinus Strobus*).
2. Southern pine (*Pinus Australis*), sap wood.
3. Southern pine, heartwood.
4. Black spruce (*Abies Nigra*).
5. Ash (*Fraxinus Americanus*).
6. Black walnut (*Juglans Nigra*).
7. Red cedar (*Juniperus Virginianus*).
8. Spanish mahogany (*Swietenia Mahogani*).
9. White oak (*Quercus Alba*).
10. Hickory (*Carya Alba*).
11. Locust (*Robinia Pseudo-acacia*).
12. Chestnut (*Castanea Vesca*).

The specimens were all of the form shown in Fig. 3, three and three-fourths inches long, with a diameter of neck of seven-eighths of an inch.

It will be noticed that, in all cases, at the commencement of the line, it rises, at a slight inclination from the vertical, and almost perfectly straight. This confirmation of Hooke's law, within the limit of elasticity, is best shown in the detached portion *a, a, a*, of the curve obtained with locust, in which the horizontal scale is somewhat magnified. The distortion is seen to be very precisely proportional to the distorting force, until the law changes at the limit of elasticity.

It will be observed that, in the larger number of cases, the torsional resistance increases with great regularity nearly to the angle of maximum stress where, suddenly, this rapid rate of increase ceases, and the limit of elastic resistance being passed, resistance diminishes rapidly with further increase of angular movement, until it becomes

*The section describing the woods is partly similar to that previously published in the "Journal of the Franklin Institute," and is here reprinted, to preserve the present more elaborate treatise unbroken, and because the study of the several plates, and their comparison was considered essential to a thorough understanding of the subject.—ED.

zero. In the tougher and more dense varieties, this decrease of resistance occurs less slowly, and in some cases only disappears after a large angle of torsion is recorded. In the curves of exceptionally strong and tough woods, in which there is known to exist a great excess of longitudinal over lateral cohesion, as in those of black walnut 6, 6, locust 11, 11, and especially in those of hickory 10, 10, a peculiarity is perceivable which is somewhat remarkable, and which is especially important in a connection to be hereafter referred to at length.

In these instances the resistance is proportional to the amount of torsion, until a maximum is reached, the line then falls as torsion continues, until a minimum is passed, the curve then again rising and passing another maximum before finally commencing an unintermitted descent to the axis of abscissas. Where the difference between longitudinal and lateral cohesion is exceptionally great, the second maximum may, as illustrated, for example, by the line described in recording the test of hickory, have a higher value even than the first. This interesting and previously unanticipated peculiarity was shown, by careful observation, to be due to the sudden yielding of lateral cohesion when the torsional moment reached the value indicated by the first minimum. The fibres being thus loosened from each other, this loose bundle of filaments yielded readily, until, by lateral crowding as they assumed a helical form and enwrapped each other, their slipping upon each other was gradually checked, and resistance again commenced increasing.

At the second maximum, yielding again began in consequence of the breaking of fibres under the longitudinal stress measured by that component of torsional force having a direction parallel with the filaments in their new positions, the exterior surface threads parting first under this tensile stress, and rupture progressing by the yielding of layer after layer, until the axial line being reached, resistance vanished. In this case, rupture seems never to occur by true shearing along one defined transverse plane. This feature of depression in the curve, occurring as described, is therefore the indication of a lack of symmetry in the distribution of resisting forces. It is evident that it may occur either by a difference in the value of cohesive force in the lateral and longitudinal directions, or by the structural defects of a specimen in which the substance itself may be endowed with cohesion of equal intensity in all directions.

The curves shown in Plate I exhibit well the relative values of these materials for the various purposes of the engineer.

White pine, 1, 1, 1, is shown by the considerable inclination of the line of stiffness from the vertical, to be soft and deficient in rigidity. The limit of elasticity is quickly reached, and the maximum resistance of the specimen is found at $15\frac{1}{2}$ foot-pounds of moment. Rapidly losing strength after passing the limit of resistance, it is entirely broken off at an angle of 130° . The small area comprised by the diagram proves its deficiency of resistance, and its inability to sustain shock.

Yellow pine, 2, 2, 2, 3, 3, 3, far excels the first in all valuable properties shown by the curve. The sapwood seems, in the specimens tested, equally stiff with the heart, but it reaches the elastic limit sooner. The general form of the diagram is the same in both, and is characteristically different from that of the white pine. It evidently has great value wherever rigidity, strength, toughness and resilience are desired in combination with lightness, the latter most important quality, together with their cheapness, aiding the qualities here shown in determining the application of these woods so extensively for general purposes. It should be noted that, since all comparisons of strength are based on measures of volume, a comparison of densities should usually be obtained to assist the judgment in making a choice from among materials of which tests have been made.

Spruce, 4, 4, 4, while possessing far less stiffness than even white pine, excels it somewhat in strength, passing its maximum at 18 foot-pounds, and submitting to a torsion of nearly 200° . It is proven to possess proportionally greater resilience also. It is, however, far inferior to the yellow pine in every respect.

Ash, 5, 5, 5, is more deficient in strength and toughness than is generally supposed, and rapidly loses its power of resistance after passing the maximum, which point is found at about $27\frac{1}{2}$ foot-pounds. These specimens may have been of exceptionally poor quality, or, possibly, were over-seasoned.

Black walnut, 6, 6, 6, is remarkably stiff, strong and resilient, its diagram resembling somewhat that of oak in general form and dimensions. The maximum of resistance reaches 35 foot-pounds, and the most ductile specimen was only broken off after yielding through an arc of 220° . Its stiffness is shown by the fact that it required a moment of 25 foot-pounds to spring it 10° , yellow pine requiring but 22 foot-pounds and spruce but 8, to give them the same amount of distortion.

Red cedar, 7, 7, 7, is very stiff, but is brittle and deficient in strength,

breaking off at 92° , and having a maximum power of resistance of but $20\frac{1}{2}$ foot-pounds. It is, however, one of the stiffest of the woods, its specimen requiring 29 foot-pounds of torsional moment to produce a total angle of torsion of but 5° .

Spanish mahogany, 8, 8, 8, is both strong and stiff, bearing a stress of 44 foot-pounds, and requiring 32 to produce torsion of 10° .

White oak, 9, 9, 9, exhibits less strength than either good mahogany, locust or hickory, but it is exceedingly tough and resilient. Passing the maximum at an angle of 15° , under a torsional stress of $35\frac{1}{2}$ foot-pounds, it retains its power of resistance nearly unimpaired up to about 70° , and then slowly yields until it suddenly gives way, after passing the angle 250° , under a strain due to 9 foot-pounds, and breaks off completely at 253° . This strength, toughness and endurance, under strains due to impact, may be attributed to its considerable lateral cohesion, and to the interlacing of its tenacious fibres, which gives this wood its "cross" grain.

Hickory, 10, 10, 10, has the highest maximum found during these experiments, the second of the pair of maxima already referred to being considerably above the maximum of locust even. This specimen exhibits well the well-known valuable properties of the material, requiring 45 foot-pounds to twist it 10° , reaching a limit of elasticity at 54 foot-pounds and 13° , and having a maximum resisting moment of $59\frac{1}{2}$ foot-pounds. When it finally yields, it does so quite rapidly, breaking off at 145° .

Locust, 11, 11, 11, gives an excellent diagram. It is the stiffest of all, yielding but 10° at its maximum of 55 foot-pounds, and one piece, which was unusually hard and compact, requiring 48 foot-pounds to distort it 4° , and reaching a maximum angle of torsion of nearly 190° .

It was noticed, during this series of experiments, that different specimens of the same species of wood usually exhibited very nearly equal strength and rigidity, and that marked differences were only occasionally noted in elasticity and resilience.

6. THE METALS, AND THE CURVES PRODUCED BY THEM.—Plate II* exhibits a series of curves which illustrate well the general characteristics and the peculiarities of representative specimens of the principal varieties of useful metals. In some cases two specimens have been chosen for illustration, of which one presents the average quality, while the other is the best and most characteristic of its class.

* See the Journal for May, 1874.

The diagrams obtained by testing metals are quite different in general character from those registered in experiments on the woods, yet there are some points of resemblance which it will be instructive to notice, since these similar characteristics indicate similar properties of the two materials, and a comparison aids greatly in the interpretation of the diagrams. The woods have a structure which differs, in a distinguishing degree, both in the distribution of the substance and in the action of these molecular forces capable of resisting rupture, from that of the metals, the latter being far more homogeneous, in both respects, than the former. Wood consists of an aggregation of strong fibres, lying parallel, or approximately so, and held together often by a comparatively feeble force of lateral cohesion. The latter force being, as often happens, destroyed, the mass becomes a collection of loose threads having the general character of a rope or cord, with slight or no twist. The metals, on the other hand, are naturally homogeneous, both in structure and in the distribution and intensity of the molecular forces. Well-worked and thoroughly annealed cast-steel, as an example, is equally strong in all directions, is perfectly uniform in its structural character, and is almost absolutely homogeneous as to strain. It would be expected, therefore, that the diagrams obtained by breaking such a material would differ from those of the woods, in having a smoother and more regular form, and this is shown to be actually the case by observation of the curves of cast-steel, cast-iron, bronze and others of the more homogeneous metals and alloys.

Some of the metals, it will be noticed, yield diagrams of less regular form. Wrought iron, as usually made, has a somewhat fibrous structure, which is produced by particles of cinder, originally left in the mass by the imperfect work of the puddler while forming the ball of sponge in his furnace, and which, not having been removed by the squeezers or by hammering the puddle ball, are, by the subsequent process of rolling, drawn out into long lines of non-cohering matter, and produce an effect upon the mass of metal which makes its behavior, under stress, somewhat similar to that of the stronger and more thready kinds of wood. In the low steels, also, in which, in consequence of the deficiency of manganese accompanying, almost of necessity, their low proportion of carbon, this fibrous structure is produced by cells and "bubble holes" in the ingot, refusing to weld up in working, and drawing out into long microscopic, or less than microscopic, capillary openings.

In consequence of this structure we find, as we should have anticipated, a depression interrupting the regularity of their curves, immediately after passing the limit of elasticity, precisely as the same indication of the *lack of homogeneousness of structure* was seen in the diagrams produced by locust and hickory.

The presence of internal strain constitutes an essential peculiarity of the metals which distinguishes them from organic materials. The latter are built up by the action of molecular forces, and their particles assume naturally, and probably invariably, positions of equilibrium as to strain. The same is true of naturally formed organic substances. The metals, however, are given form by external and artificially produced forces. Their molecules are compelled to assume certain relative positions, and those positions may be those of equilibrium, or they may be such as to strain the cohesive forces to the very limit of their reach. It even frequently happens, in large masses, that these internal strains actually result in rupture of portions of the material at various points, while in other places the particles are either strongly compressed, or are on the verge of complete separation by tension. This peculiar condition must evidently be of serious importance, where the metal is brittle, as is illustrated by the behavior of cast-iron, and particularly in ordnance. Even in ductile metals it must evidently produce a reduction in the power of the material to resist external forces. This condition of internal strain may be relieved by annealing hammered and rolled metals, and by cooling castings very slowly, in order that the particles may assume, naturally, positions of equilibrium. In tough and ductile metals, internal strain may be removed by heating to a high temperature and then cooling under the action of a force approximately equal to the elastic resistance of the substance. This process, called "Thermo-tension," was first used by Professor Johnson in the course of his experiments as a member of a Committee of the Franklin Institute, in 1836,* and the effect of this action in apparently strengthening the bars so treated, was stated in the report of the committee. The fact that this effect was very different with different kinds of iron was also noted, but it does not appear that the cause of this, which they term "an anomalous" condition of the metal was discovered by them.

Metals which are very ductile may frequently be relieved of internal strain, also, by simply straining them while cold to the elastic

* Journal Franklin Institute, 1836-7.

limit, and thus dragging all their particles into extreme positions of tension, from which, when released from strain, they may all spring back into their natural and unstrained positions of equilibrium. This fact, which does not seem to have been previously discovered by investigators of this subject, will be seen to have an important bearing upon the resisting power of materials, and upon the character of all formulas in which it may be attempted to embody accurately the law of resistance of such materials to distorting or breaking strain.

Since straining the piece to the limit of elasticity brings all particles subject to this internal strain into a similar condition, as to strain, with adjacent particles, it is evident that indications of the existence of internal strain, and through such indications a knowledge of the value of the specimen, as effected by this condition, must be sought in the diagram, before the sharp change of direction which usually marks the position of the limit of elasticity is reached. As already seen, the initial portion of the diagram, when the material is free from internal strain, is a straight line up to the limit of elasticity. A careful observation of the tests of materials of various qualities, while under test, has shown that, as would, from considerations to be stated more fully hereafter, in treating of the theory of rupture, be expected, this line, *with strained materials, becomes convex towards the base line*, and the form of the curve, as will be shown, is parabolic. The initial portion of the diagram, therefore, determines readily whether the material tested has been subjected to internal strain, or whether it is homogeneous as to strain. This is exhibited by the *direction* of this part of the line as well as by its form. The existence of internal strain causes a loss of stiffness, which is shown by the deviation of this part of the line from the vertical to a degree which becomes observable by comparing its inclination with that of the line of elastic resistance, obtained by relaxing the distorting force — *i. e.*, the difference in inclination of the initial line of the diagram and the lines of elastic resistance, *e, e, e*, indicates the amount of existing internal strains.

FORGED IRON.—In Plate II, the curves numbered 6, 1, 22 and 100 are the diagrams produced by three characteristic grades of wrought-iron. The first is a quality of English iron, well known in our market as a superior metal. The second is one of the finest known brands of American iron, and the third is also of American make, but it does not usually come into the market in competition with well-known

irons, in consequence of the high price which is consequent upon the necessary employment of an unusual amount of labor, in securing its extraordinarily high character.

No. 6 at first yields rapidly under moderate force, only about 50 foot-pounds of torsional moment being required to twist at 5° . It then rapidly becomes more rigid, as the internal strains, so plainly indicated, are lost in this change of form, and at 6° of torsion, the resistance becomes 60 foot-pounds, as measured at a . Here the elastic limit is reached. The next 3° produce no increase of resistance. The fact shows that this iron, which was not homogeneous as to strain, is also not homogeneous in structure. We conclude that it must be badly worked and seamy, and that it may have been rolled too cold; the former is the probable reason of its lack of homogeneous structure, the latter gave it its condition of internal strain. After the first 9° of torsion, resistance steadily rises to a maximum, which is reached only when just on the point of rupture, and the piece finally commences breaking at 250° , and is entirely broken off at 285° . Its maximum elongation, whose value is proportionable to the reduction of section noted with the standard testing machines, is 0.691. The terminal portion of the line, after rupture commences, is not usually accurate as a measure of the relation of the force to the distortion. The increase of resistance between the angle 9° and the angle of rupture is produced by the additional effort in resistance due to the "flow" or drawing out of particles, as already indicated, and the precise effect of which will be noticed at length in a succeeding section relating to the theory of rupture.

Applying the scale for tension, which in the case of these curves was very exactly 24,000 pounds per square inch for each inch measured vertically on the diagram, we find that the elastic limit was passed under a stress equivalent to a tension of 19,800 pounds per square inch, and that the ultimate tenacity was 59,200 pounds per square inch. When nearly at the maximum the specimen was relieved from stress, the pencil descending to the base line, and the elasticity of the piece produced a certain amount of recoil. The angle intercepted between the foot of this nearly vertical line, c , and the origin at O , measures the *set*, which is almost entirely permanent. The distance measured from the foot of the perpendicular, let fall upon the axis of abscissas, from the head of this line to the foot of the line e , measures the elasticity, and is *inversely proportional to the modulus*. A comparison of the inclination of the line made by the pencil in

reascending, on the renewal of the strain with the initial line of the diagram, gives the indication of the amount of internal strain originally existing in the piece.

It will be noticed that the horizontal movement of the pencil is recommenced at *L*, under a higher resistance than was recorded before the elastic line was formed. In this case the piece had been left under strain for some time before the stress was relieved, and the peculiarity noted is an example of an increase of resistance under stress,* or more properly of *the elevation of the elastic limit*, of which more marked examples will be shown subsequently.

The exceptional stiffness and limited elastic range here shown, as compared with the other examples given, is probably a phenomenon accompanying and due to this increase of resistance under stress.

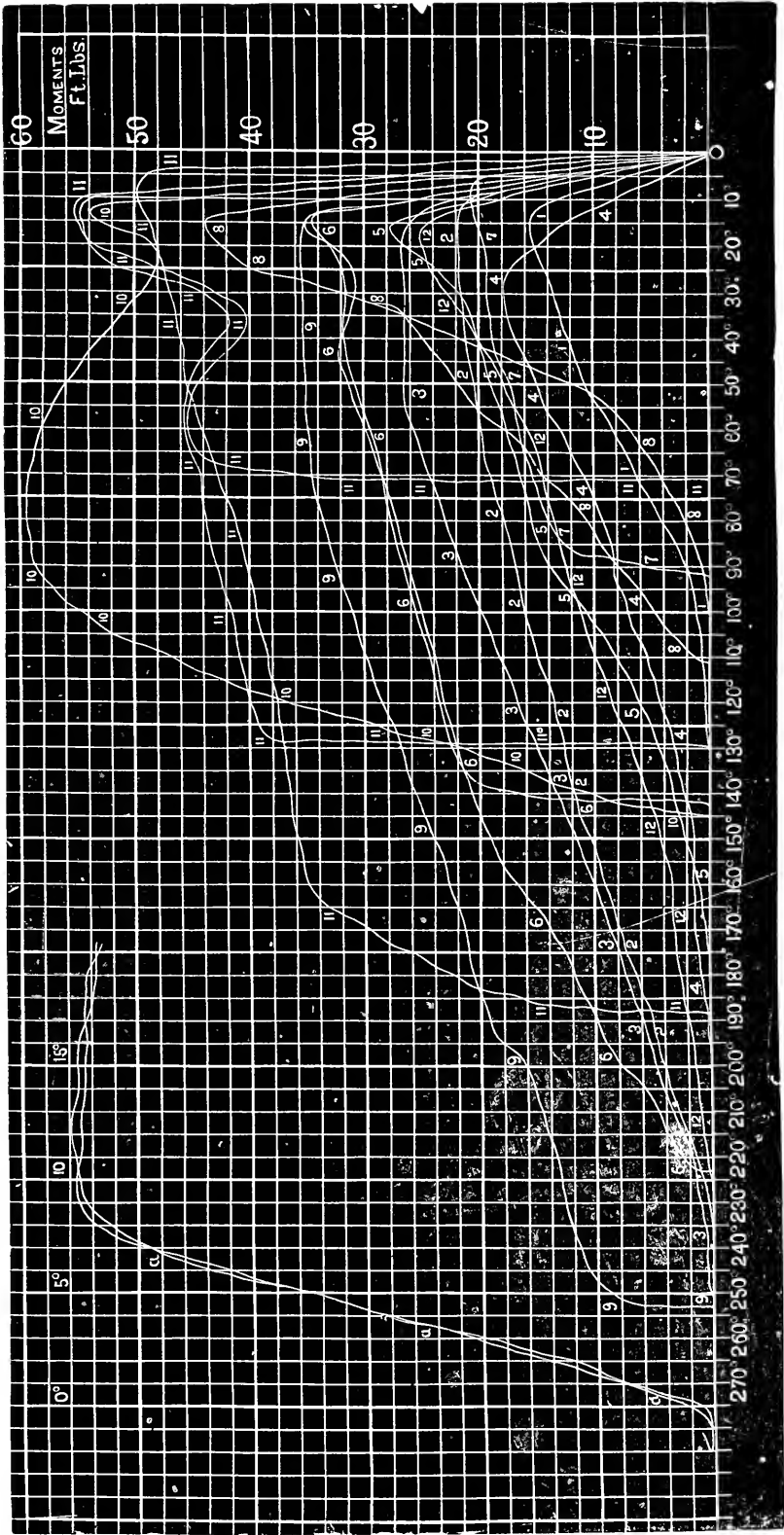
Examining No. 1 in a similar manner, we find that it is far freer from internal strain than No. 6, its initial line being much more nearly straight and rising more rapidly. It is rather less homogeneous in structure, and is forced through an arc of 6° , after having passed its elastic limit, before it begins to offer an increasing resistance. It is evidently a better iron, but less well worked, and, as shown by the position of the elastic limit, is somewhat harder and stiffer. No. 1 retains its higher resistance quite up to the point at which No. 6 received its incidental accession of resistance by standing under strain, and the two pieces break at, practically, the same point, No. 1 having slightly the greater ductility. When the "elastic line," *e*, is formed, just before fracture, it is seen that No. 1 has a greater elastic range and a lower modulus than No. 5. It should be observed that the line by which the pencil *descends* to the base line has usually no value, owing to the fact that no care is generally taken to remove the stress as gradually as it is applied. When such care is taken, the lines are usually coincident, and do not form the loop here seen. It will also be noticed that these lines often cross each other, that on the right being the important line. The elastic line formed by No. 1 at between 40° and 45° of torsion is seen to be very nearly parallel with that obtained near the terminal portion of the diagram, and illustrates the fact here first revealed to the eye, that *the elasticity of the specimen remains practically unchanged up to the point of incipient rupture*, and this fact corroborates the deductions of Wertheim* and others who came to this conclusion from less

* *Vide* Transactions, Vol. II, page 290.

AUTOGRAPHIC STRAIN-DIAGRAMS OF WOODS

PRODUCED BY THE

Testing Machine of PROF. R. H. THURSTON.



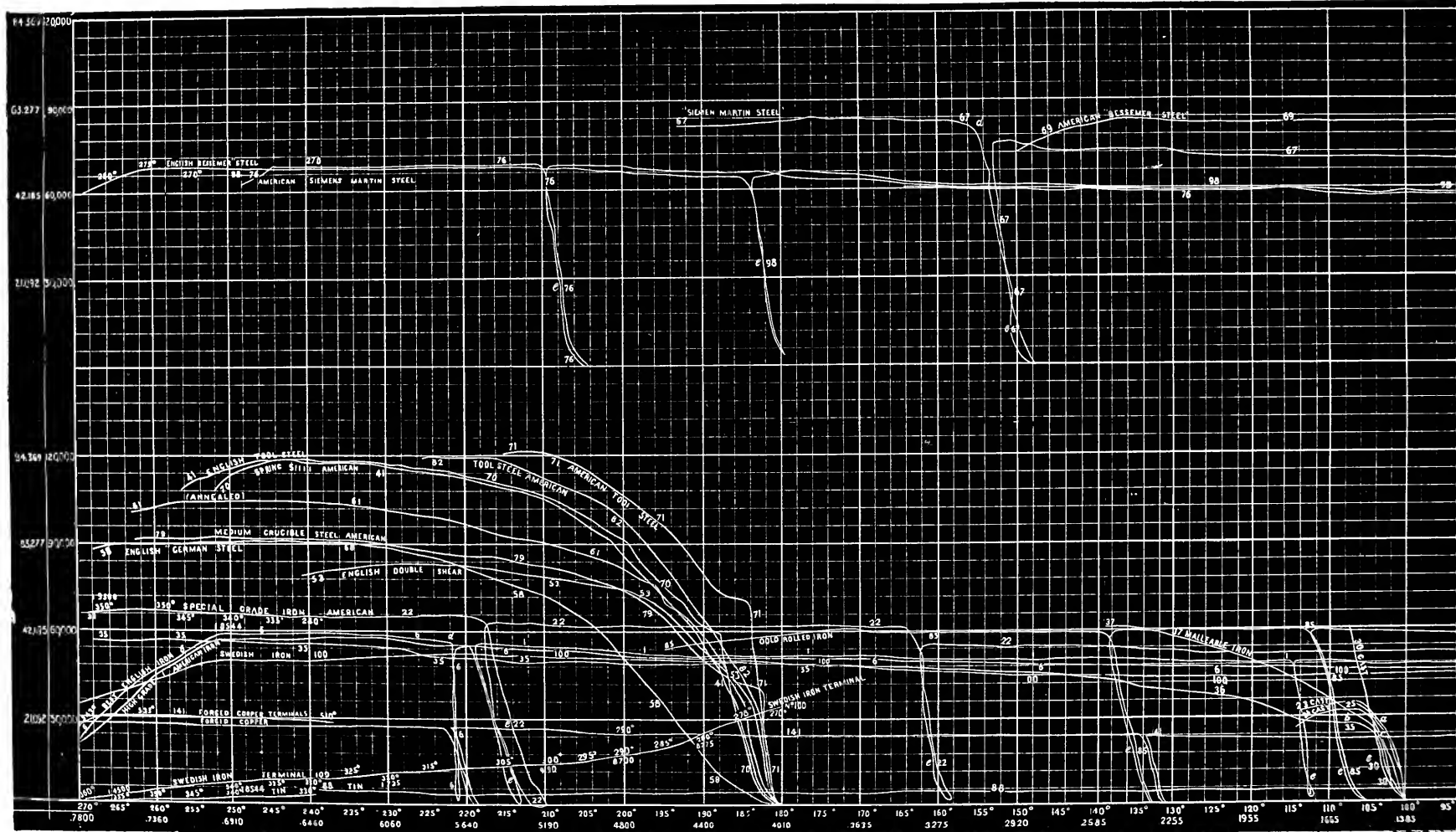
APPROXIMATE
TENSILE RESISTANCE.

Kilograms Pounds per
per square square inch
Millimetre. of Section.

AUTOGRAPHIC STRAIN-DIAGRAMS OF

PRODUCED BY THE

TESTING MACHINE OF PROFESSOR R. H. THURSTON.

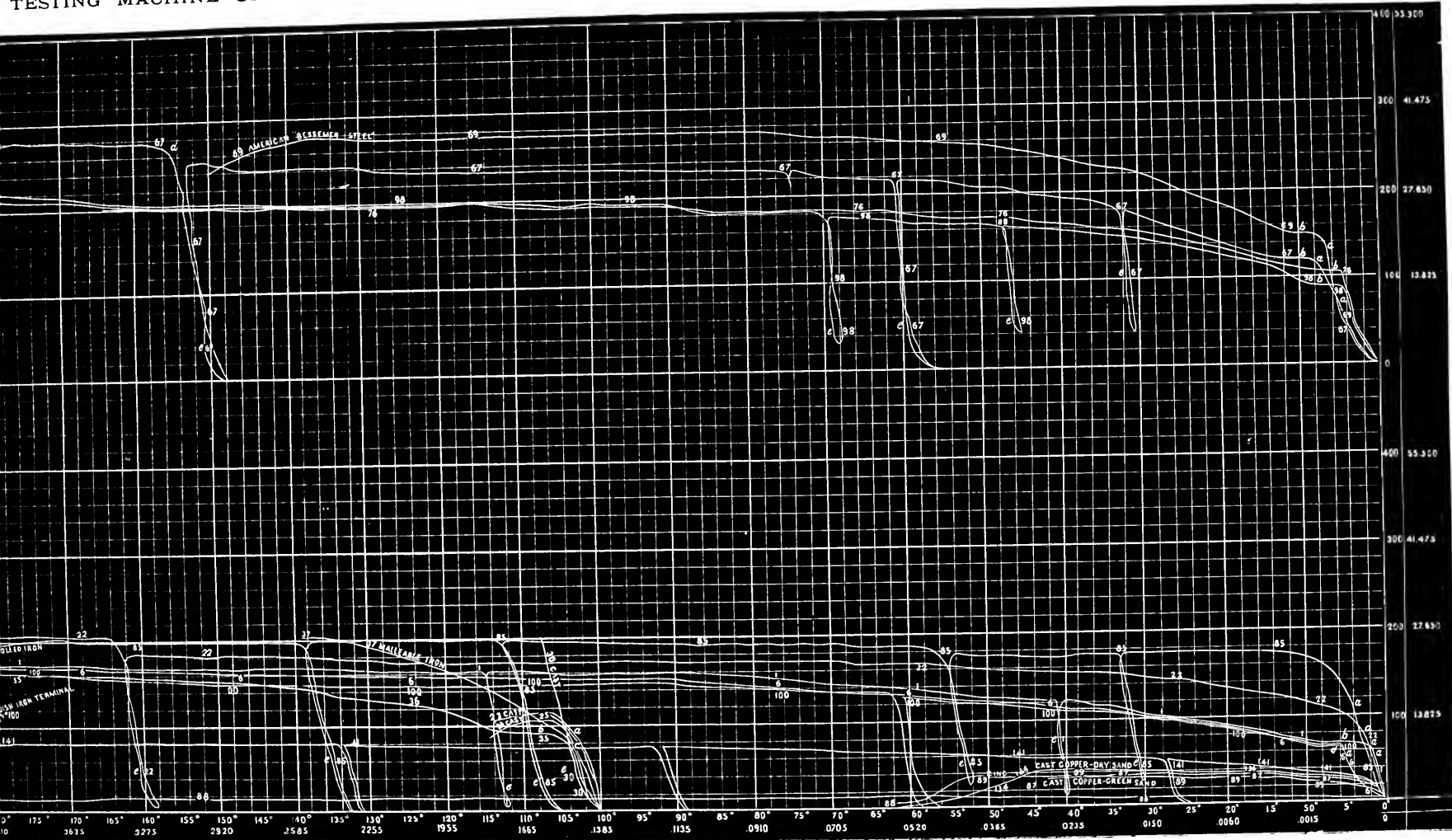


Angle of Torsion
Elongation.

GRAPHIC STRAIN-DIAGRAMS OF METALS

PRODUCED BY THE

TESTING MACHINE OF PROFESSOR R. H. THURSTON.

Torsional Moments.
Foot-Pounds, Kilogram-
metresAngle of Torsion
Elongation.



satisfactory modes of research. All experiments yet made give a similar result.


No. 22 illustrates the characteristics of a metal which probably represents one of the best qualities of wrought iron made in this or in any other country, and with which every precaution has been taken to secure the greatest possible perfection, both in the raw material and in its manufacture. The fact that it finds a market at sixteen cents a pound proves that even such care and expense are well applied. The line of this diagram, starting from *O*, rising with hardly perceptible variation from its general direction, turns, at the elastic limit, *a*, under a moment of about 80 foot-pounds, equivalent to a tension of about 24,000 pounds per square inch; and with between 2° and 3° of torsion only, and thence continues rising in a curve almost as smooth and regular as if it had been constructed by a skilful draughtsman. Reaching a maximum of resistance to torsion of 220 foot-pounds and an equivalent tensile resistance of over 66,000 pounds per square inch, at an angle of 345° , it retains this high resistance up to the point of rupture some 358° from its starting point. The maximum elongation of its exterior fibres is 1.2, making them at rupture 2.2 times their original length. This would produce a probable breaking section in the common testing machine equal to 0.4545 of the original section.†

From the beginning to the end this specimen exhibits its superiority, in all respects, over the less carefully made irons, Nos. 1 and 6, which, it should be remembered, are themselves deservedly known as good brands. The homogeneousness of No. 22 is almost perfect, both in regard to strain and to structure, the former being indicated by the straightness of the first part of the diagram and its parallelism with the "elastic line," *e*, produced at $217\frac{1}{2}^{\circ}$, and the latter being proven by the beautiful accuracy with which the curve follows the parabolic path indicated by our theory as that which should be produced by a ductile homogeneous material. At similar angles of torsion, No. 22 offers invariably much higher resistance than either Nos. 1 or 6, and this superiority, uniting with its much greater ductility, indicates an immensely greater resilience. It is evident that for many cases, where lightness combined with capacity to carry live

* *Vide* Annales de Chimie et de Physique.

† Compare Kirkaldy: Strength of Iron and Steel; pp. 111, 135, for reduction in Yorkshire and Swedish bars. The elongation there given has, of course, no value as a measure of ductility.

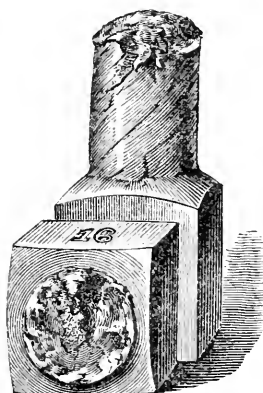
loads and to resist heavy shocks are the essential requisites, this iron would be by far preferable, notwithstanding the cost of its manufacture, to any of the cheaper grades. Comparing their elasticities, as shown at 210° , 215° , it is seen that No. 22 is about equally stiff and elastic with No. 1, while both have a wider elastic range and are less rigid, and hence are softer than No. 6, whose elastic line is seen at 221° . All of the characteristics here noted can be accurately gauged by measuring the diagrams, and constants are readily obtained for all formulas, as illustrated in a later section of this paper, in which the construction of formulas and the determination of constants will be made the subject of investigation.

No. 100 is the curve obtained from a piece of Swedish iron, marked . Its characteristics are so well marked that one familiar with the metal would hardly fail to select this curve from among those of other irons. Its softness and its homogeneous structure are its peculiarities. Its curve, at first, coincides perfectly with that of No. 6. It has, however, slightly less of the condition of internal strain, and a somewhat higher limit of elasticity. The elastic limit is found at $5\frac{1}{2}^{\circ}$ of torsion, and at a stress of 65 foot-pounds of moment, equivalent to 19,500 pounds on the square inch, in tension. Its increase of resistance, as successive layers are brought to their maximum and begin to flow, is very nearly the same as that of the specimens Nos. 1 and 6, and the line lies between the diagrams given by these irons up to 30° , and then falls slightly below the latter. At 220° , it attains a maximum resisting power, and here the outer surface begins to rupture, after an ultimate stretch, of lines formerly parallel to the axis, amounting to 0.564. Had this elongation taken place in the direction of strain, as in the usual form of testing machine, it would have produced a reduction of section to 0.64, the original area.* At this point the stress in tension equivalent to the 176 foot-pounds of torsional stress, is 52,800 pounds per square inch. From 250° the loss of resistance takes place rapidly, but the actual breaking off of the specimen did not occur until it had been given a complete revolution. This part of the diagram distinguishes the metal from all others, and shows distinctly the exceptionally tough, ductile and homogeneous character which gives the Swedish irons their superiority in steel making. No. 22, even, although much more extensible, is harder than No. 100, and yields more suddenly when it finally gives way.

* Compare Styffe ; *Strength of Iron and Steel* ; p. 133, Nos. 26—30.

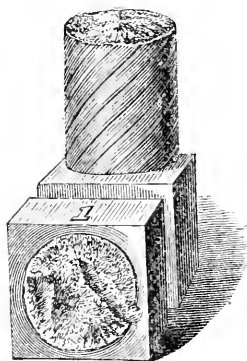
A comparison of the results here recorded with those obtained by Styffe,* will afford a good basis upon which to form an idea of the accuracy as well as the convenience of this method of deriving them. An examination of the broken test piece gives some evidence confirmatory of the record. The exterior surface of the twisted portion has an appearance intermediate between that of No. 1, Fig. 5,† and No. 22, Fig. 7, with an evident tendency to “kink.” The surface of fracture is lighter and more lead-like than even No. 22, and its “fibre” is finer and texture more plastic in appearance. It is beautifully uniform in character. On one end of this specimen, where a piece had been nicked and then broken off by a sharp blow, the absence of all fibrous appearance, and the granular texture and magnificently fine, regular grain are very marked, and indicate that the material is entitled to its es-

Fig. 6.



tablished position as the purest metal known in the market. The specimens themselves furnish almost as valuable information, after test, as the diagrams contain, and should always be carefully inspected with a view to securing additional or corroborative information. Fig. 5 is a sketch of specimen No. 1, and shows its somewhat granular fracture, and the seamy structure produced by a defective method of working. Fig. 6, from specimen No 16, more nearly resembles that which gave the diagram marked 6. The metal is seen to be good, tough, and better in quality than No. 1, but it is even more seamy, and even less thoroughly worked, as is evidenced by the cracks extending around the neck, and by the irregularly distributed flaws seen on its end.

Fig. 5.



No. 7 exhibits the appearance of No. 22 after fracture, and shows,

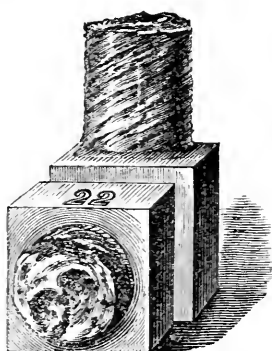
* As on last page.

† From an article in the “Scientific American,” of January 17th, 1874, on Testing the Quality of Iron, Steel and other Metals without Special Apparatus.

even more perfectly than the pencilled record, the splendid character of the material. The surface of the neck was originally smoothly turned and polished, and carefully fitted to gauge. Under test it has become curiously altered, and has assumed a rough, striated appearance, while the helical markings extend completely around it. The end has the peculiar appearance which will be seen to be characteristic of tough and ductile metals, and the uniformly bright appearance of every particle in the fractured section shows how all held together up to the instant of rupture, and that fracture finally took place by true shearing. Rupture by torsion thus brings to light every defect and reveals every excellence in the specimen. Rupture by tension rarely reveals more than the mere strength of the material.

(To be continued.)

Fig. 7.



On the Lighting of Gas by Electricity.—The old apparatus for lighting the hall of the French National Assembly, in which the ignition of fine platinum wire was made use of, having been replaced by an induction apparatus, the irregularity of its action induced an examination of it by M. Gaiffe. He observed that the coil itself sometimes transmitted no spark, and he was led to believe that this arose from the production of an induced current in the contiguous wires which entirely neutralized and vitiated the first. He accordingly arranged a miniature apparatus exactly like the one actually in use, except that a galvanometer was included in the circuit. From his experiments he concludes that the spark really is due to two distinct currents: one, the brilliant straight spark of the coil proper; the other, the duller and enveloping flame or aureola surrounding it, which arises from the induction of a secondary current moving in the inverse direction. Of course this latter current weakens the former; and hence M. Gaiffe remarks that it is not possible to limit the action of an induction coil to a single circuit, when several such circuits are to be successively worked by its agency.

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EDITORIAL.

ITEMS AND NOVELTIES.

Alloys of Iron and Manganese.—The Terre-Noire Iron Company has recently taken out a patent in France for the preparation of alloys of iron with tungsten, titanium, silicon and manganese. The method which they employ for this purpose is the following :

Scrap iron and filings or turnings of cast or wrought iron or of steel, or even iron sponge coarsely pulverized, or any other iron or steel *debris*, in a more or less analogous state of division, is mixed with the minerals containing the tungsten, titanium, manganese, etc., or all of them together, or with quartz, these substances being all finely pulverized; the proportions in which the mixture is made determining the character of the alloy. The mass is then sprinkled, either with an ammoniacal solution or with a dilute acid, so as to moisten it completely and uniformly, and submitted to compression in a suitable mould. Considerable heat is evolved, and, at the end of a few hours, when the mould is opened, a very hard, compact mass is obtained, which may be broken, under the hammer, into fragments of any desired size. These fragments resist perfectly a red heat, and begin to crumble only when the cast iron they contain begins to melt. Treated in the ordinary way, in a suitable high furnace, they yield alloys of great value, the ferro-manganese containing from 25 to 50 per cent. of manganese, the ferro-silicon containing as high as 22 per

cent. of silicon. Ferro-tungsten and ferro-titanium, or even mixtures of all four together, may also be obtained in this way, but they require specially constructed furnaces, since the temperature at which they are obtained is so high that, to attain it, the blast must enter at a very high temperature and under a very great pressure. Moreover, under these conditions, especially in presence of the active base contained in the furnace-lining, the walls are very rapidly attacked, particularly in the lower portions. For this reason they have constructed their furnaces as follows :

The shaft is composed of refractory brick, as hard as possible, in which alumina predominates ; the hearth is made of lime, of manganese, or of pure alumina, and the crucible is made of carbon, of lime, and of magnesia. This carbon crucible is formed in a single piece by moulding a mixture of pure graphite or of gas carbon or coke with coal tar in a strong sheet iron case. It is then heated in a close vessel to a dull red heat for several hours. A very hard, compact mass is obtained in this way, without cracks and without joints. The hearth is contained in a single case of iron plate, and is attached by dowels to the cast iron plate which holds the crucible. This crucible is movable, and is applied against the lower portion of the hearth, being retained by pressure ; so that it may be changed at will. Beneath it is a foundation of masonry. This arrangement allows the renewing of the parts of the furnace most liable to wear, in a very short time. The blast is heated at least to 350° C., and enters under a pressure of from 13 to 15 centimetres (5 or 6 inches) of mercury.

It may increase the interest of this description to add some information concerning the experiments which have been made by the Terre-Noire Company, under the direction of M. Tessie du Motay, and the results which they have obtained.

It is well known that the use of manganiferous ores for the production of Bessemer pig irons, and especially for that of the spiegel-eisen, which is run into the converter near the end of the Bessemer process, is indispensable in order to obtain those qualities of steel which are in demand for industrial uses, particularly for railroad purposes. Attempts have been made to avoid this necessity by introducing the manganese in fragments directly into the converter ; but the pulverulent condition of the metal has always rendered its use in this way impracticable. By their success in preparing these solid cakes of ferro-manganese, containing a high percentage of manganese, the Terre-Noire Company have obtained a first result of very great value.

They have not confined themselves, however, to the results already attained. Seeking to extract from this first success everything of value which it contained, the inventors very naturally had in view the elimination of phosphorus, which has, until now, rendered it impossible to use in the high furnaces in which Bessemer pig iron is made, any ores which contain this substance, and which has prevented the use of old rails in the Siemens-Martin furnace. Employing the well-known purifying action of manganese, as well as of certain other reagents, to effect this elimination, they have not, indeed, succeeded in rendering it complete, a notable quantity of phosphorus being obstinately retained. But, at the same time, they have recognized the important fact that their products, containing now only traces of carbon and a maximum quantity of only four thousandths of phosphorus, possess all the qualities most desirable for the best steel rails; that is, homogeneity, elasticity, resistance to rupture, and especially resistance to compression. In a word, their products recall, but with all the superiority of steel to iron, the eminently good qualities of the iron rails made from the oolitic ores of Mazenay, d'Hayange, etc.

Almost complete decarburization, then, both of the Siemens-Martin and the Bessemer steels, permits the retention of an amount of phosphorus which, without this, would be entirely inadmissible; that is to say, these two metalloids, carbon and phosphorus, are incompatible with each other when both are present; but when either is present separately, an alloy is obtained having special properties, and which may be called carbon steel or phosphorus steel.

The slabs of ferro-manganese produced by the Terre-Noire Company are sold in the market at present at from $2\frac{1}{2}$ to $3\frac{1}{2}$ francs the kilogram (25 to 35 cents per pound). As it is necessary to add but two per cent. of it to the charge in order to obtain the remarkable results above given, some idea may be formed of the importance of this discovery.

Special ores being no longer necessary for the production of these steels, old products of inferior composition being now equally available, no doubt can arise that a vast field is opened by this discovery to iron masters, from which the railroad industry will derive important benefit. These results, too, it should be remembered, are not merely theory; they have been realized practically, and already large quantities of the new rails made in this way are in service on different French railways. We should note here, too, the remarkable

agreement of these results with those above mentioned as long ago observed, with iron rails made from phosphorus ores, an agreement practically confirmed by their use on railways.

Iron Mines in Algeria.—Iron mining in Algeria is daily taking a vastly increased importance. The ores are of excellent quality, and are already in great demand. The first mine opened, that of Ain-Mokhra, better known under the name of Mokta-el-Hadid, is developing an unlooked-for richness, the present production, although somewhat interfered with by the war, exceeding 30,000 tons a month. To transport the ore to Bône, where it is shipped, eight trains are run per day, each carrying 200 tons. England and the Netherlands are large purchasers of it, and it has already been shipped in considerable quantities to this country. Its price averages 27 francs per ton, the cost of transportation into France being 9 f. 50c. additional. In 1872, 366,614 tons were mined. In the first six months of 1873 the amount taken out was 220,000 tons. In the entire industry of this mine, including the mining proper, the railroad, the depot at Bône, and the shipping, 1542 workmen are employed, an increase of 378 over the number employed during the previous year. At a distance of 44 kilometers (27 miles) from Setif, on the old road from Bougie, called the Setif post route, occurs the important Djebel mine, and near Aïn-Rouah another very rich mine has been opened on the side of the mountain and well explored by means of shafts and galleries. The right to work this mine has been accorded by the Government to Nœvus, Nicolas & Company, and it is proposed to employ at once 800 miners. The ore will be shipped, at the port of Bougie, direct to all parts of the world.

Bauxite and the Aluminum Industry.—Bauxite, a mixed iron and aluminum hydrate, is the best ore of aluminum. It is found at several localities in France. That of Aubagne is not yet developed. That exported from Provence comes from the quarries of Cabasse, in the Department of Var, and those at the foot of the southern watershed of the Alps in the arrondissement of Tarascon. These latter quarries, however, furnish products rich in iron, generally silicious, which are employed mostly for fixing the hearths of iron furnaces. The Cabasse mineral is quite free from silica, and is best suited for the manufacture of aluminum and its salts, and is also largely used for refractory fire bricks. The main uses of the Cabasse bauxite are:

1st. For the manufacture of chemical products ; the works of Ludwigshafer, on the Rhine, using 1000 to 1200 tons of this mineral annually.

2d. For the manufacture of fire-bricks ; M. Durschmidt, of Lyons, consuming it largely in making parts of the cylindrical furnaces of M. Siemens.

3d. For the production of artificial emery ; certain varieties being worked into whetstones and sharpening stones, for various purposes demanding hardness and abrading power.

At the Luc station, the nearest point of shipment to Cabasse, the price of the bauxite is from 16 to 17 francs per ton.

The New Blake Hose.—A hose to meet the requirements of fire service must be eminently light, compact and impervious, as well as durable and easily kept in order. Leather hose is heavy and filthy, requiring constant oiling ; while the demerits of the “ four-ply ” gum hose are its extreme bulk and weight, and its rapid decay. Unlined canvas hose is light and strong, but not impervious. Seamless rubber-lined hose does not admit of perfect union between the envelope and its lining. In order to meet this objection, the Blake hose is made by calendering pure gum *through* the pores of strong duck, then coating each side with pure rubber, sewing the fabric up and vulcanizing the whole together. Both rubber and duck are mildew-proofed. The new hose is light and strong, occupying little space, and is warranted for three years.

Hydropneumatic Pump for Transmitting Power.—At the February meeting of the Société d'Encouragement, M. Haton, in behalf of the Committee on the Mechanic Arts, made a report on a hydropneumatic pump, invented by M. Jarre, engineer and director of the Ornans Company. He says : “ The problem of transmitting power to great distances is always one of great interest. But when the direction along which the power is to be transmitted from the motor to the point of application is crooked and beset with intervening obstacles, the transmission of motion itself is one of great difficulty, and is well nigh insoluble if we are limited to the employment of shafts of invariable dimensions. M. Jarre uses compressed air for transmitting the power of the motor, making it act directly upon water without the intervention of a piston. As the pressure in the air-tube, produced by the force pump placed at a distance from the water to be raised, varies but little, it is necessary to provide some

apparatus to render the effect of this pressure in the ejection cylinder an alternating one, so that this cylinder may be filled through an inlet valve and then emptied through a second valve opening outwards. This M. Jarre has accomplished by a sort of hydraulic cata-ract, based on the principle of the intermittent fountain, well known in physical cabinets. An oscillating balance beam alternately admits or shuts off the compressed air from the surface of the water to be raised, according to the variations in weight which take place in the two movable portions of the apparatus, either when immersed or when in the air; that is to say, when the water-level is raised or lowered. The action of the compressed air is made to follow very readily the motion of the water in the general operation of the machine, the pump continuing its action indefinitely so soon as the pressure of the moving air is sufficient.

Several pumps of the same general sort have been brought into use within the last two or three years. There is a certain disadvantage, without doubt, in having the air act upon the liquid directly, because the useful portion of the pressure given by the compression apparatus is in this way limited to the fixed pressure of the ascending column of liquid and the loss by the tube. But this inconvenience is compensated by certain special advantages, which make this apparatus of great value in certain cases. For example, one of these pumps is placed 150 metres (500 feet) from the motor, the compressed air being conducted to it by a tube 0.02 metres ($\frac{3}{4}$ inch) only in diameter, having in this distance twenty-four bends at right angles. The water raised, which is 75 litres ($16\frac{1}{2}$ gallons) per minute, issues from a tube 0.04 metre ($1\frac{1}{2}$ inches) in diameter, having nine bends at right angles in its course, and narrowed also by two cocks. It is difficult to conceive of a method by which, under these conditions, motion could be transmitted to such a distance by means of metallic shafting. Moreover, the hydraulic mechanism, since it requires no attention, and is liable to no accident, will undoubtedly, under many circumstances, have a decided preference over the ordinary pumps for raising water.

The Committee on the Mechanic Arts return their thanks to M. Jarre for his interesting communication made to the Society, and recommend the insertion of this Report in the Bulletin, together with a drawing of the machine.

Strength of Riveted Joints.—In consequence of the results obtained in an extended series of experiments made by Mr. Fairbairn,

relative to the resistance of bolts or rivets when used to unite together metallic plates, he asserts :

1st. That joints made with drilled holes are weaker, and elongate less before rupture, than those made by the use of punched holes.

2d. That hand-riveted joints are somewhat more resistant than joints riveted by machinery.

3d. That the resistance of the rivets to rupture is considerably increased if the edges of the holes are first rounded, so as to diminish their cutting action.

Artificial Coloration of Wine.—In a note communicated to the Pharmaceutical Society of Bordeaux, at a recent meeting, M. Carles give some of the methods which he has employed for the detection of artificial coloring matters in wine. Among the various substances used for this purpose, the author enumerates hollyhocks, cochineal in ammonia, myrtle berries, and aniline red. Regarding the methods of analysis thus far in use defective as well as somewhat difficult of execution, M. Carles proposes a new and simple method, which is at the same time exact and easily available; it is based on the changes of color which artificially colored wines undergo when subjected to the influence of a large quantity of water, of an excess of gelatin, or, better, white of egg, or ammonia. All pure wines preserve their color when mixed with 100 to 150 times their volume of water; they become slightly green by the action of ammonia and are decolorized by agitation with an excess of albumen. These reactions are very sharp when they are obtained in a deep vessel with a white bottom, like a coffee cup, for example; they are often sufficient for the detection of a foreign coloring matter. Other and special tests are applied to prove the presence of individual colors, as that of phytolacca, elderberry, hollyhock, myrtleberry, cochineal in ammonia, etc. The following is the method of procedure :

The suspected wine is mixed with water in the proportion of two to five parts of wine to 250 parts of water. Two cases then arise :

1st. *The wine preserves its color or turns violet.* If now it is for the most part decolorized by albumen, and is turned decidedly green by ammonia, it is pure.

If it is turned yellow by ammonia, phytolacca.

“ “ “ blue “ “ cochineal.

“ “ decolorized by ammonia and by acids, rosaniline.

2d. *It becomes green before, or better after, fining.* Then (1) if it

becomes violet on adding aluminum acetate, and gives a red precipitate with basic lead acetate, the color is due to elderberry. If the basic lead acetate gives a bluish-green precipitate, the color is due to hollyhock. (2) If it be turned green by aluminum acetate, myrtle-berry gives the color.

When dealers in and manufacturers of wine improve the color of their products by adding fuchsine, a salt of rosaniline, they commit not simply a fraud, but also an attempt upon the health of the consumer. The toxical properties of this substance has been long ago proved by decisive experiments. It cannot but be of use, therefore, to the community to devise processes by which the presence of fuchsine in a vinous liquid may be detected. To the test for this substance we have given above, we add the following: Fifty grams ($1\frac{1}{2}$ ounces) of the wine is introduced into a white glass bottle, whose capacity is 120 to 130 cubic centimetres (four ounces) and treated first with 20 grams basic lead acetate and then with the same quantity of amyl alcohol. If now, after vigorous agitation, the liquid appears colorless, this is proof that the wine was not colored by fuchsine. But if, on the contrary, it possesses a red tint, this is proof that the wine has received color from this poisonous substance. This test is based on the fact, 1st, that the coloring matter of pure wine is precipitable by basic lead acetate, while fuchsine is not thrown down by this reagent. And, 2d, that amyl alcohol, which dissolves both when they are free, has no longer any action on œonine when combined with lead, while it still retains the power of removing fuchsine from the liquid.

Valuation of Commercial Indigoes.—M. Henry Bergé, Professor of Applied Chemistry in the University of Brussels and chemist to the city, has recently published a report on the valuation of indigoes, especially of those obtained by the new Sayers process. He says: The new process of Joseph Sayers, for extracting the coloring matter from the indigo-plant, is a wonderful step in advance of previous methods. Without taking into the account the rapidity and the almost mathematical precision of this method—without considering the considerably greater yield which is given by it—it is sufficient to compare the analyses of the indigoes prepared by the Sayers method with those of the ordinary commercial indigoes, in order to prove the enormous superiority in quality of the former over the latter.

I have made comparative analyses of twenty-four specimens of in-

digo, of which ten were of various origins and fourteen were extracted by the Sayers process. The ten commercial samples were delivered to me by M. Schalknyck, an indigo broker in Rotterdam, and included six specimens of Java indigo, two of Bengal indigo and two of Manilla indigo. The following table gives the marks, the prices and the composition of these several indigos :

District and Marks.			Blue coloring matter, or indigotin.	Mineral mat- ters or ash.
Java Indigo,	SK	75 centimes.	57.19	14.28
" "	ABCD	125—	27.28	44.47
" "	KP	225—	55.13	9.02
" "	GWG	460—	68.68	5.09
" "	WJF	550—	69.82	2.18
" "	CFE	600—	75.78	2.69
Bengal Indigo,		450—	72.17	2.93
" "		525—	75.36	1.99
Manilla Indigo,		60—	14.47	45.63
" "		125	24.55	37.98
Sayers Java Indigo,	No. 1		69.37	2.31
" " "	" 2		72.35	2.82
" " "	" 3		74.03	2.59
" " "	" 4		69.32	3.48
" " "	" 5		66.98	4.25
" " "	" 6		65.38	3.95
" " "	" 7		69.63	2.89
" " "	" 8		71.20	1.53
" " "	" 9		71.40	2.36
" " "	" 10		74.53	1.61
" " "	" 11		71.11	2.14
" " "	" 12		67.89	2.76
" " "	" 13		67.85	2.66
" " "	" 14		76.70	2.50

A special characteristic of the indigos extracted by the method of M. Sayers is the very small quantity of mineral matters or ash which they contain; thus, for example, the mean results of the above analyses of the ten samples of ordinary commercial indigo is 16.62 per cent. of ash; while the average content of ash in the Sayers specimens is only 2.77 per cent.—a difference in favor of the latter of 13.85 per cent. Moreover, the richness in indigotin is very remarkable in the Sayers samples; the yield is 70.58 per cent. as a mean;

and it never descends below sixty-five or sixty-six per cent. Bengal indigo, coppery, good ordinary, contains as a mean only 61.4 per cent. Sometimes very fine Bengal or Java indigos are obtained which contain as high as seventy-five and even eighty per cent. of indigotin; but these are exceptional products. The market affords, it is assumed, ten per cent. of good indigo, thirty-five per cent. of average quality, and fifty-five per cent. of ordinary indigo. Of course, we are now speaking of good, genuine, merchantable indigos, and not those subsequently treated or falsified.

From these facts, it appears that not ten per cent. of the indigos of commerce contain more than from sixty-five to sixty-six per cent. of indigotin; but this is the minimum proportion yielded by the Sayers process of extraction. The importance of this method, then, in the preparation of a substance as high in price and as extensively used as indigo, is sufficiently obvious from these analyses, guaranteed, as they are, by the reputation of M. Bergé.

Editorial Correspondence.

INCREASE OF RESISTING POWER OF METALS UNDER STRESS.—[In the March number of this Journal, reference was made to a memorandum by Commander Beardslee, relating to certain experiments made by this gentleman upon some specimens of old chain iron, the results of which confirmed the recent novel discovery announced by Prof. R. H. Thurston, that metals left under stress during periods ranging from one to several days really gained in power of resistance. We have recently received the accompanying statement, prepared by Com. Beardslee in continuation of the subject, which furnishes a most conclusive confirmation of the discovery of Prof. Thurston.—ED.]

Editor of Journal of Franklin Institute :

DEAR SIR,—I send you herewith the results of a series of experiments which I have collated while engaged in testing some old chain iron on hand. The machine in which the tests were made is the "Dynamometer" belonging to the Ordnance Department. The iron was generally of a low grade of tensile strength. The test specimens

EXPERIMENTS TO DETERMINE THE LIMIT OF TENSILE STRENGTH OF IRON.

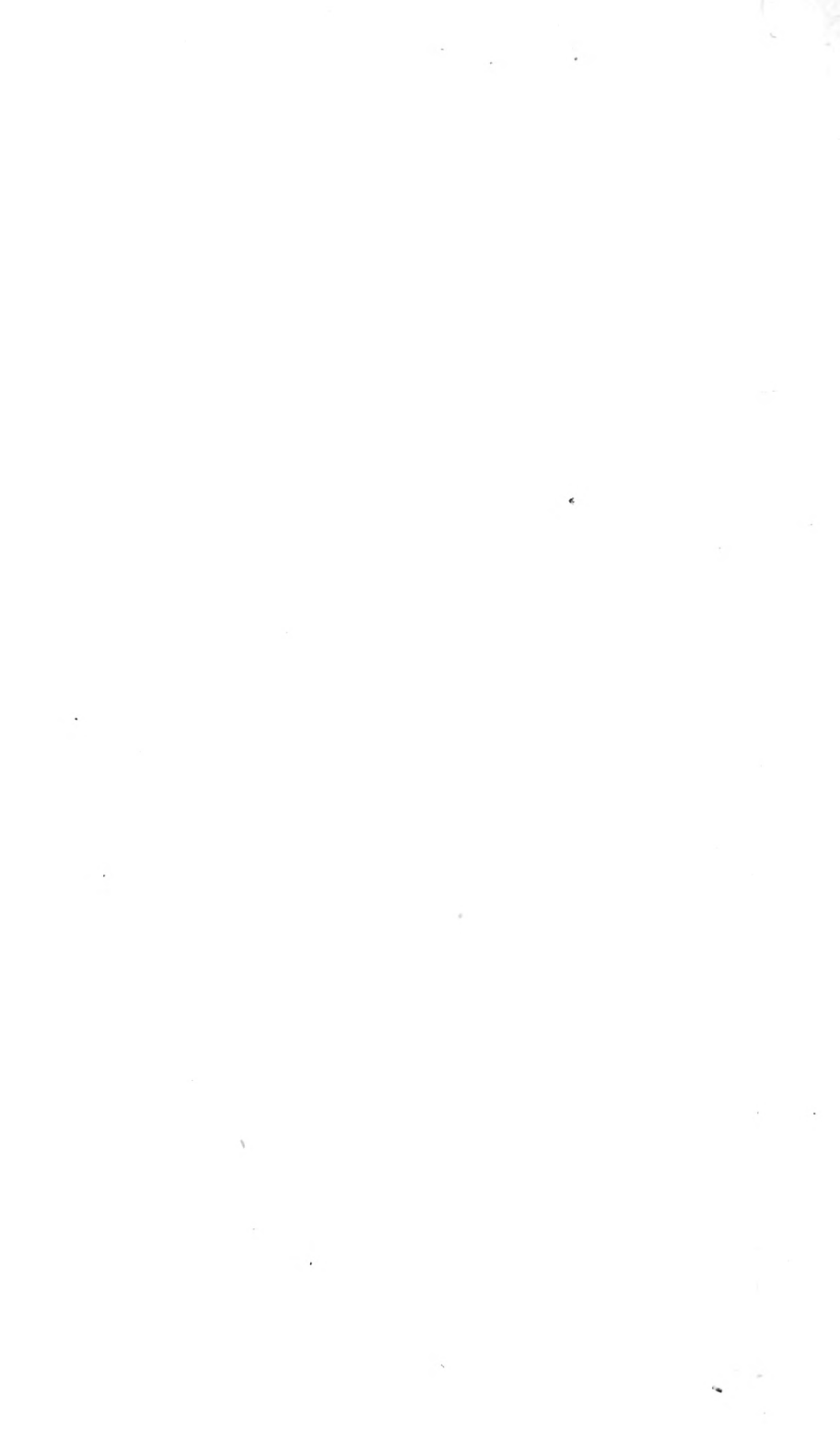
TABLE No. 1.

No.	Limit of Elasticity.			Increase.	Increase per cent	Increase per sq. inch.	Length.		Diameter.		Remarks.
	1st strain.	Hours inter-vening	2d strain				Before	After.	Before.	After.	
	lbs.		lbs.	lbs.		lbs.	inches	inches.	inch.	inch.	
1	24 300	in 17	28 250	3 950	16	7 900	2 $\frac{9}{16}$		1 $\frac{3}{16}$		Bloom hammered, from old boiler plate
2	24 900	out 16	28 550	3 650	14.6	7 300	2 $\frac{9}{16}$		1 $\frac{3}{16}$		Old boilers and mixed scrap.
3	23 900	in 16	29 000	4 000	16.7	8 000	2 $\frac{9}{16}$		1 $\frac{3}{16}$		Same bloom.
4	25 100	in 16	27 000	1 900	7.6	3 800	2	2 $\frac{6}{16}$	1 $\frac{10}{16}$		Turned from 1 $\frac{3}{8}$ inch chain iron. Fibrous.
5	25 800						2	2 $\frac{6}{16}$	1 $\frac{10}{16}$		Piece from same link. Broke on first strain.
6	24 050	out 16	27 200	3 150	13.1	6 300	1 $\frac{11}{16}$	2 $\frac{6}{16}$	1 $\frac{11}{16}$		Turned from 1 $\frac{3}{8}$ inch chain iron. Fibrous.
7	24 075	in 16	27 750	3 675	15.3	7 350	1 $\frac{11}{16}$	2 $\frac{6}{16}$	1 $\frac{11}{16}$		Same link.
8	25 125	in 16	26 600	1 475	5.9	2 950	2	2 $\frac{6}{16}$	1 $\frac{11}{16}$		Turned from 1 $\frac{3}{8}$ inch chain iron. Coarse and granulous.
9	25 350	out 16	27 650	2 300	9.	4 600	2	2 $\frac{6}{16}$	1 $\frac{11}{16}$		Same link.
10	24 800	in 16	26 450	1 650	6.7	3 300	2	2 $\frac{6}{16}$	1 $\frac{11}{16}$		Turned from 2 inch chain iron. Granulous.
11	25 600	out 16	26 450	850	3.4	1 700	2	2 $\frac{6}{16}$	1 $\frac{11}{16}$		Same link.
12	14 700	out 16	16 125	1 425	9.7	5 700	1 $\frac{9}{16}$	1 $\frac{11}{16}$	1 $\frac{7}{16}$		Turned from 1 $\frac{1}{2}$ inch chain iron. Fibre dark and coarse.
13	14 750	in 16	16 450	1 700	11.5	6 800	1 $\frac{9}{16}$	1 $\frac{11}{16}$	1 $\frac{7}{16}$		Same link.
14	13 000	in 16	14 800	1 800	13.8	7 200	1 $\frac{9}{16}$	1 $\frac{11}{16}$	1 $\frac{7}{16}$		Turned from 1 $\frac{5}{16}$ inch chain iron. Fibre foundry cast and granulous.
15	13 200	out 16	14 175	975	7.4	3 500	1 $\frac{9}{16}$	1 $\frac{11}{16}$	1 $\frac{7}{16}$		Same link.
16	14 100	out 40	15 150	1 050	7.4	4 200	1 $\frac{9}{16}$	2 $\frac{1}{16}$	1 $\frac{7}{16}$		Turned from 1 $\frac{1}{16}$ inch chain iron. Close fibre.
17	13 600	in 40	15 500	2 300	16.9	9 200	1 $\frac{9}{16}$	2	1 $\frac{7}{16}$		Same link.
18	14 350	in 16	16 050	1 700	11.1	6 800	1 $\frac{9}{16}$	2 $\frac{1}{16}$	1 $\frac{7}{16}$		Turned from 1 inch chain iron.
19	14 500						1 $\frac{11}{16}$	2 $\frac{5}{16}$	1 $\frac{7}{16}$		Broke first strain.

Nos. 8, 9, 10 and 11 of above table were subjected to further strains, until finally broken, with results as follows:

TABLE No. 2.

No.	1st strain.		Interval.	2d strain.		Difference.	Per cent.	Interval.	3d strain.		Difference.	Per cent.	Interval.	4th strain.		Difference.	Per cent.	Interval.	5th strain.		Difference.	Per cent.	Breaking strain.	Lever balanced at ter				
	lbs.	hours.		lbs.	lbs.				hours.	lbs.				lbs.	hours.				lbs.	lbs.				hours.	lbs.	lbs.	1st strain.	2d strain.	3d strain.	4th strain.
8	25-125	in 16		26-600	+1-475	5.9		in 7	27-350	+ .750	2.7		in 41	27-250	- .100	3.		in 7	27-000	- .250	.9		lbs.	24-150	25-550	25-100		lbs.
9	25-350	out 16		27-650	+2-300	9.		out 7	26-575	-1-075	4		out 41	28-300	+1-725	6.1		out 7	27-000	-1-300	4.6			24-300	26-700	25-875		
10	24-800	in 16		26-450	+1-650	6.7		in 8	25-500	- .950	3.7		in 16	27-400	+1-900	6.9		in 4	26-500	- .900	3.4		23-475	23-950	25-125	24-500	25-950	
11	25-600	out 16		26-450	+ .850	3.4		out 8	27-450	+1-000	3.6		out 16	26-375	-1-075	4.1		out 4	25-875	- .500	1.9		22-850	24-700	25-625	25-600	25-600	



were prepared by turning down pieces $3\frac{3}{4}$ inches long, leaving a cylinder of 2 inches in length and $\frac{1}{16}$ (nearly) in diameter, for a section equal to $\frac{1}{2}$ square inch area, and to $1\frac{9}{16}$ in length, $\frac{9}{16}$ in diameter (nearly) for a section of $\frac{1}{4}$ square inch area. A head was left at each end for the purpose of clamping in the machine.

The crank was turned at a uniform rate of about 32 revolutions per minute; the amount of strain was indicated upon a lever, which constantly rose as in an ordinary beam scale. When the "limit of elasticity" is reached, the lever ceases to rise, and falls; if then the strain be increased there will be no corresponding rise to the lever, but the sample will presently break. At the instant the lever ceases to rise the amount of strain is noted and recorded. At this point the weights in each case were taken from the lever until it balanced; the following were the deductions:

On the chain iron, $\frac{1}{2}$ square in. area, 780, 875, 900, 800, 800, 875, 850, 900 lbs.; average, 857 lbs.

On chain iron, $\frac{1}{4}$ sq. in. area, 550, 625, 675, 750, 550, 600, 600 lbs.; average, 612 lbs.

On the scrap iron of $\frac{1}{2}$ sq. in. area, 1050 lbs. and 1225 lbs.

The pieces were generally tested in pairs, one piece being taken from the machine when the limit of elasticity was reached, and the other left under stress for the same period, generally from 3 P.M. till 7 A.M. next day, when both were broken. In each case the falling of the lever at the first strain was slow, and it required close attention to mark accurately. In the succeeding strains the lever would drop suddenly.

An analysis of Table 1 shows that the percentage of gain between first and second strains was as follows:

Six tests, $\frac{1}{2}$ sq. in. area, left under stress, increased 16 p. c., 16.7 p. c., 7.6 p. c., 15.3 p. c., 5.9 p. c., 6.7 p. c., or, on an average, 11.3 p. c. (nearly).

Four tests, $\frac{1}{2}$ sq. in. area, left without strain, increased 14.6 p. c., 13.1 p. c., 9 p. c., 3.4 p. c., or, on an average, 10 per cent.

Leaving out No. 11, which seems an extreme, the average would be 12.2 per cent.

Four tests, $\frac{1}{4}$ sq. inch area, left under strain, increased 11.5 p. c., 13.8 p. c., 16.9 p. c. and 11.1 p. c., or an average of 13.4 p. c.

Three tests, $\frac{1}{4}$ sq. in. area, taken out from the machine, increased 9.7 p. c., 7.4 p. c. and 7.4 p. c., an average of 8.2 p. c. (nearly).

The average per cent. increase in all the tests is 10·8 per cent. on the figures of the first strains.

After the second pull, it was considered that the specimens had no more life, and they were broken by a few more turns of the crank, the lever being down and making no response.

The Commandant suggested a continuation of the strains, and Nos. 8, 9, 10 and 11 were pulled, at intervals, until broken, as per Table 2.

In making this second series it was noticeable that the greater portion of the increase in length, and contraction of diameter, occurred at the first pull, very slight changes taking place on after pulls until the fifth strain, when, before breaking, they stretched, and diminished nearly $\frac{1}{8}$ and $\frac{1}{16}$ of an inch.

These experiments having been carried on in connection with other duty, have not the value that a series of more careful ones would have, in which the iron should be uniform, and the temperature and other conditions noted. They, nevertheless, point to a curious result, evidently not that of accident.

Very respectfully,

L. W. BEARDSLEE, *Commander, U. S. N.*

Washington, April 8, 1874.

Editor of Journal of Franklin Institute :

DEAR SIR,—Since writing the article on the use of the polar planimeter in the calculation of earth work and for other purposes, which appeared in the last number of your "Journal," I have had occasion to use the planimeter in the ordinary course of my business. I am convinced of its value as a regular office instrument, and, willing to aid in its introduction generally among engineers and others, have made arrangements with Messrs. Buff & Berger, astronomical and surveying instrument makers, of this city (9 Province court), by which they are enabled to receive orders for polar planimeters, to be graduated under my personal supervision, and each instrument to be accompanied by plain and concise directions for its use; the graduation and the directions to be drawn, moreover, with reference to the special wants of each customer.

Yours very truly,

CLEMENS HERSCHEL, *Civil Engineer.*

Boston, April 11, 1874.

Civil and Mechanical Engineering.

IMPROVEMENT OF THE OHIO RIVER.*

BY FELIX R. BRUNOT, OF PITTSBURGH.

The improvement of river navigation is of greater national importance in the United States than in any of the Old World countries. Our magnificent distances, the wide dispersion of heavy wealth-creating elements, such as coal, ores and lumber, the often long distances between the points of origin and consumption of both these and the products of the soil, and the great length and adaptability of our rivers to the purposes of cheap transportation, should make the subject of their improvement, to the highest degree of their capability, one of transcendent interest.

That such a stream as the Ohio, susceptible of being made to convey the traffic of a hundred railroads throughout its length of nearly a thousand miles, by the expenditure of a sum less than the cost of a single railroad from Philadelphia to Pittsburgh, should be suffered to remain in its natural condition, is, to say the least, discreditable to the nation.

Congress, claiming, as it does, the entire control of the stream, is chiefly responsible for the fact that the Ohio still remains useless for a large portion of the year. Let Congress but consent to give up its control for the purpose of improvement, and many men could be found, any one of whom would undertake to raise, by the ordinary methods of public enterprises, the sum necessary to convert the Ohio, from its source to its mouth, into a perennially navigable river. Few would desire that the Ohio, or that other great heritage and highway of the nation—the Mississippi—should ever become the property of a private corporation; certainly the writer is not among the number. The thought is only introduced to set forth in a stronger light the apathy of the Government in permitting so great an element of economy and wealth to remain so long unavailable. Again and again the grand statistics of the existing commerce of the great rivers have been laid before Congress, with the only petty results of a few thou-

* "*Radical Improvement of the Ohio River.*" Report of G. WEITZEL, Major of Engineers, Brevet Major-General U. S. A., and W. E. MERRILL, Major of Engineers and Brevet Colonel, to GEN. A. A. HUMPHREYS, Chief of Engineers. U. S. A. Congressional Document, Feb. 12th, 1874.

sands of dollars spasmodically appropriated to "remove snags" or "complete wing-dams;" and again and again the process has been repeated, until the task of raising Congress to a reasonable estimate of the national importance of the subject has hitherto seemed to the patient millions of the Ohio and Mississippi Valleys well nigh hopeless.

The report of Gen. Weitzel and Col. Merrill puts a new aspect on the affair, and in connection with the present demonstration of the agricultural, industrial and commercial interests of the country in favor of cheap transportation, it is difficult to see how the present Congress can fail to take the preliminary steps towards a radical improvement of both the Ohio River and the Upper Mississippi, from St. Paul to St. Louis.

Messrs. Weitzel and Merrill were, by appointment of the War Department, constituted a Board to examine certain proposed plans, and after mature consideration of the capabilities of the river and the requirements of its trade, to recommend, if possible, some system for the radical improvement of the Ohio. The results of a year of intelligent and laborious investigation and experiment by the Board are set forth in their report, which has lately been published by Congress, and is a document of ninety-six Congressional pages.

The Board, in the beginning of their report, after stating the object of their appointment, and referring to their preliminary report of May 1, 1872, remark:—

"As this report did not reach Congress, no appropriation was made. Since then the Board has been actively engaged in studying the history of similar works in this country and abroad, and in testing, by large models, all the various plans that appeared likely to answer the purpose. *They are now fully prepared to submit a plan which they feel confident will fully meet the necessities of the case.*"

A brief reference to some of the old methods and propositions for the improvement of river navigation may aid in reaching a correct appreciation of the importance of this announcement.

ANCIENT AND MODERN METHODS.

All rivers, except the short and comparatively small streams which are supplied from springs or perpetually melting snows in summer, are subject to great variations in the quantity of water flow. Many of them, of considerable size and navigable for a part of the year, could be made navigable at all times were it possible to hold back the

flood water and supply it day by day, as required, through a channel reduced in area by artificial means. This plan of reservoirs and channel, either natural or artificial, has been used for time immemorial for purposes of irrigation or canal navigation.

Mr. Telford, sixty years ago, proposed to improve the navigation of the river Severn by making reservoirs among the hills of Montgomeryshire, which he claimed would also serve to regulate the floods of the stream; but Rennie, another noted English engineer, condemned the plan as "ridiculous."

Mr. Chas. Ellet, a distinguished engineer, became imbued with a similar idea in regard to the Ohio River, and expended much time in an able attempt to demonstrate its feasibility.

Mr. W. Milnor Roberts, C. E., has shown conclusively that, owing to the magnitude of the stream, its extraordinary floods, the rapid descent and flow of its originating tributaries, the impossibility to find reservoir sites available to collect and retain a sufficient quantity of the rain fall, and for other reasons, the plan as proposed is impracticable. That reservoirs may be found useful adjuncts to whatever system of improvement may be adopted is, however, agreed upon by Mr. Roberts and all the engineers who have written upon the subject.

OPINION OF HENRY CLAY.

When Mr. Ellet's plan was under discussion in the United States Senate on a proposition to appropriate money for surveys, it was advocated by Mr. Clay, who said that "for less money than the cost of a custom-house in New York or Boston, we may effect an object for which I contend that if *twenty millions* were applied, and the object could be accomplished with that amount of money, *it would be a profitable, just and national appropriation of the public funds.*"

This remark of that eminent statesman indicated what his convictions were as to the duty and correct policy of the Government, and atones for his oft-quoted slur upon the noble river, which, he said, was "frozen up half the year and dry the other half."

Where rivers have a gentle and uniform flow, and a broad bed, it is manifest that when the supply of water decreases so as to render them too shallow for navigation, some degree of improvement may be made by contracting the width of channel. For instance, if the water flow is 200 feet wide and one foot deep, by contracting it to one-half of the width you will have substantially a flow of one hundred feet wide and two feet deep. If this contraction were made by

actually building out the banks for the whole length of the stream, or, to use a word coined by English engineers, *canalizing* it, the difficulty is created that in floods the water-way would be insufficient, and the stream must necessarily overflow its banks.

To narrow the channel and yet avoid the overflow, the system of *jetties*, or, as the French call them, *barrages*, was adopted. The jetties are weirs, or dams, projecting from the shore of each side of the stream to the required distance, so as to throw all the water into a contracted channel. They are generally of rough stones or boulders, and low enough to be beneath the surface of the water at moderate stages, and are usually not in pairs opposite to each other, but alternating.

Seven hundred years ago this system was used in Egypt to check the rapidity of streams and improve their navigation. The jetties were made opposite to each other, and the passage in low water was narrowed or stopped by planks, which were removed for the passage of boats, and replaced as required. It is known also that more than 300 years ago the Chinese had a similar arrangement upon their rivers, and that they have it yet.

Mr. Robert Fulton, in his treatise on River Navigation, speaks of a like system in Flanders at a very early day.

In all parts of the civilized world great improvements have been made upon this primitive plan; yet, strange to say, it is substantially the system which has been pursued up to this time upon the Ohio River. The United States Government—ahead of all the world in so many things—is, so far as the improvement of the Ohio navigation is concerned, about 700 years behind all the civilized countries of Europe.

A single paragraph in the report of the U. S. Engineers demonstrates the utter inadequacy of the system of jetties, or, as we call them, wing dams, for the proper improvement of the Ohio River. Speaking of White's ripple and the Trap, 11 miles below Pittsburgh, they say, "Here the whole body of water passes through a space whose width at low water is 230 feet, and yet at that stage the depth for navigation is frequently but 12 inches."

Herman Haupt, Esq., Civil Engineer, proposed, in 1855, an improvement of the system, which consisted substantially in the *canalization* of the river, the proposed open channel to be 200 feet wide. It is evident from the above quotation that such a channel would give no satisfactory result.

W. Milnor Roberts, C. E., published an able and important paper in the "Journal of the Franklin Institute," in 1857, proposing the system of "Locks and dams with sluice-ways or chutes for descending navigation." Subsequently, Mr. Roberts, when in charge of the Ohio River improvement, advocated the same system, with the addition of adjustable gates or dams to close the sluices in low water, and which he deemed practicable.

Gen. Weitzel and Maj. Merrill have been led by their investigations to conclusions which may best be given in the language of their report. They say :

"In the Upper Ohio by far the most important navigation is the transport of coal. Pittsburgh annually ships over 50 million bushels to points below, and all the large cities from Cincinnati to New Orleans receive their principal supplies from this source and in this way. Under existing arrangements all this coal comes out on floods of 7 feet or more, a single steamboat bringing down from eight to twenty barges. The representatives of this interest, although not content with the river as it is, would prefer no change unless it were of such a character that they would have no more delay or trouble in getting their fleets down the river than they have now. Coal fleets are so large and ponderous that they require a wide river for manœuvring; and, besides, the barges must be bound together in every direction in the firmest possible manner by cables and screw-clamps. It is very tedious and difficult to make up a coal fleet, and somewhat hazardous; and it is almost indispensable when the boats are once firmly connected they should remain so until the whole fleet is landed at its destination. For this reason the passage of a lock after the fleet has started is most objectionable, and would cause insupportable delay and danger. The coal interest of Pittsburgh is therefore a unit in opposing the erection of any dam in the Ohio River unless some modification can be introduced into the ordinary slack-water system that will permit the passage of fleets without requiring them to be broken up and re-formed below the dams.

* * * * * It may, therefore, be considered as settled that the adoption of the system of locks and dams on the Ohio River is dependent upon the practicability of making an opening in each dam of sufficient width to pass a coal fleet without any delay, of constructing a movable hydraulic gate to open or close this opening at will, and of building a chute or inclined plane of such length and shape that there will not be an excessive velocity in it nor any objectionable wave at its entrance or its exit.

"The average width of a coal fleet is 125 feet. The least width of chute that can now, in advance of experience, be assumed as necessary is 200 feet. The first question, therefore, is, can a gate be constructed that can be made to close or open this passage at will?"

When we consider the volume and force of a body of water 200 feet wide, and from 3 to 10 feet deep, rushing on with a velocity of

four or five miles an hour, to be stopped or set free at will by a gate which must present no obstacle in itself or the machinery for working it, either above or below the water, to obstruct the passage of boats, or be liable to damage from ice or freshets, the desideratum may well seem impracticable; how ponderous and strong the gate must be to resist the weight and surge of water; what power or machinery can handle the massive structure?

A similar problem in regard to their own rivers has engaged the attention of the most distinguished French and English engineers for 30 years, with progressive success, and there are now in daily use upon their rivers more than a dozen plans, all of which are found to be improvements on the obsolete jetty system.

Following the passage already quoted, Messrs. Weitzel and Merrill remark:

"The following extracts from Hagen and Becker, two of the most prominent writers on hydraulics, will show what has thus far been done in this country and in Europe in cases similar to the one with which we have to deal. After discussing generally the uses of the movable dams and their importance, Hagen proceeds to enumerate the different plans which have been suggested, prefacing it with the remark that no one seems yet to furnish a full solution of the problem. He then says: 'A complete solution of the problem seems to require that the pressure of the water, whether standing or flowing, should furnish the power by which the dam is erected or removed. Or, again, the construction must be such that, notwithstanding the requisite solidity of the structure, it can be managed with a slight power, for which only a few men and short time are required.'"

EXEMPLIFICATION OF THE FRENCH SYSTEM.

The report then proceeds to collate from the above-named authorities, and other sources, accurate descriptions of thirteen or more of the best systems in use upon European rivers.

The following is an abbreviated description of some of the works being executed by the French Government. It is cited in the report from the "Annales des Ponts et Chaussées"

"The great water route connecting Havre, Rouen and Paris with Lyons and Marseilles, by the Seine and Yonne rivers, the Burgundy Canal and the rivers Saone and Rhone (see map on plate 6), had, until September, 1871, a very defective section; in fact, a veritable gap, 118 miles long, between Paris and Laroche, where the Burgundy Canal enters the Yonne. In fact, for eight or nine months in the year, from March to November, the descent of loaded boats was only possible, especially on the Yonne, twice a week, by the aid of artificial floods or waves from the upper Yonne, and the draught of water available varied from 2½ feet to 3 feet four inches, and 3 feet 7 inches at most; so that

boats from the Burgundy Canal, drawing from 3 feet 7 inches to 4 feet 7 inches, were obliged to break bulk at Laroche. As to ascending craft, they were generally empty, or only carried a few tons of merchandise. This costly, slow, and altogether insufficient navigation, was accompanied by great fatigue, by danger, and by numerous accidents. Although it was somewhat less difficult on the Seine, navigation was much hindered, and often stopped, between Montereau and Paris. Since the 1st of September, 1871, there has been a continuous navigation between Paris and Laroche, thanks to 17 movable dams constructed on the Yonne, and to 2 cut-offs and 12 movable dams constructed on the Seine. The minimum depth of water in the pools is 5 feet 3 inches, and therefore boats can move up and down with perfect safety, drawing from 4 to 5 feet. At present, while the works are yet incomplete, the greatest part of the loads, especially those that come from the Nivernais Canal, do not draw over 4 feet; but when the works of the same kind (that is, 8 movable dams and one cut-off, now being built between Laroche and Auxerre, where the Nivernais Canal enters) are finished, which will be by the end of this year (1873), the great advantages will be happily realized which the government had in view, and which were looked for with impatience, but with confidence, by the boating, commercial, industrial and agricultural interests.

* * * * *

“The works for improving the navigation between Montereau and Laroche, authorized in 1861, were nearly completed in 1868, when a continuation up the Yonne to Auxerre was ordered. These new works were commenced in 1869, and although retarded by the war with Germany, will probably be completed by the end of the present year. These new works consist of eight movable dams (of which seven have locks), one cut-off, dredging, bank-protection and minor works. The dam of La Chainette, just below Auxerre, has a navigation-pass 138 feet wide, closed by a Poirée needle-dam and a permanent weir 656 feet long, whose top is even with the surface of the post. The sole of the navigation pass is 20 inches below low water. The chamber of the lock attached to the dam is 27 feet wide, and has an available length of 305 feet. This dam was built under the old system of creating temporary floods. The seven new dams have navigation-passes varying in width from 98 to 115 feet, closed by Chanoine wickets, with their soles 2 feet below low water. The weirs, whose soles are 20 inches above low water, are from 82 to 131 feet in length. Six of these weirs have needle-dams on the Poirée system, and one has large Girard shutters 11½ feet wide, with a vertical height of 6½ feet.”

The navigation-passes on the upper Seine and Yonne are from 98 to 211 feet in width, according to circumstances and locality.

The low water discharge on the upper part of the Yonne is 459 cubic feet per second, and the average slope of the stream is 3½ feet per mile, and on the lower part the flow is 600 cubic feet per second, and the slope 1 foot 10 inches per mile.

Let us compare the capacity out of which this navigation has been created with that of the Ohio. The low water discharge of the Ohio at Wheeling, with only 1 foot of water on the bar, is 1700 cubic feet

per second. The average slope between Pittsburgh and Wheeling is about 10 inches per mile, and between Wheeling and Cincinnati only $6\frac{3}{4}$ inches per mile.

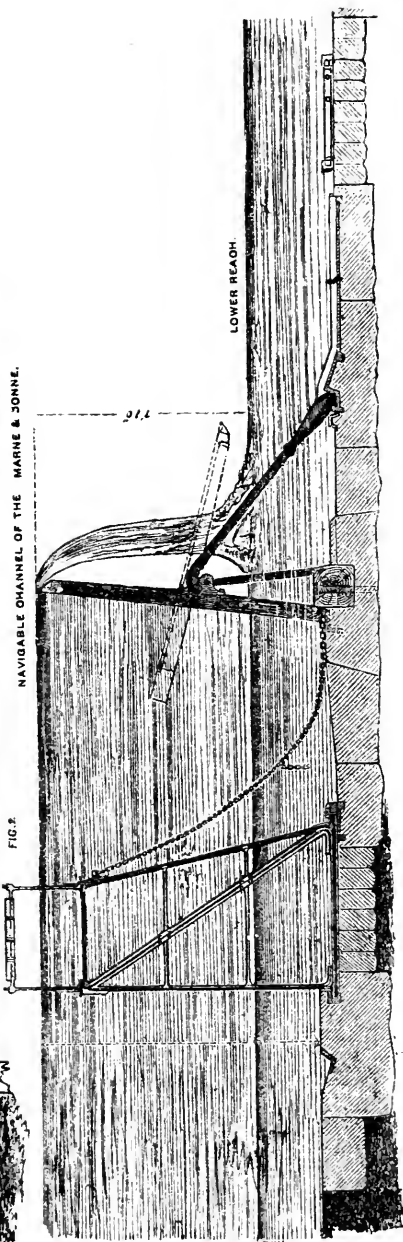
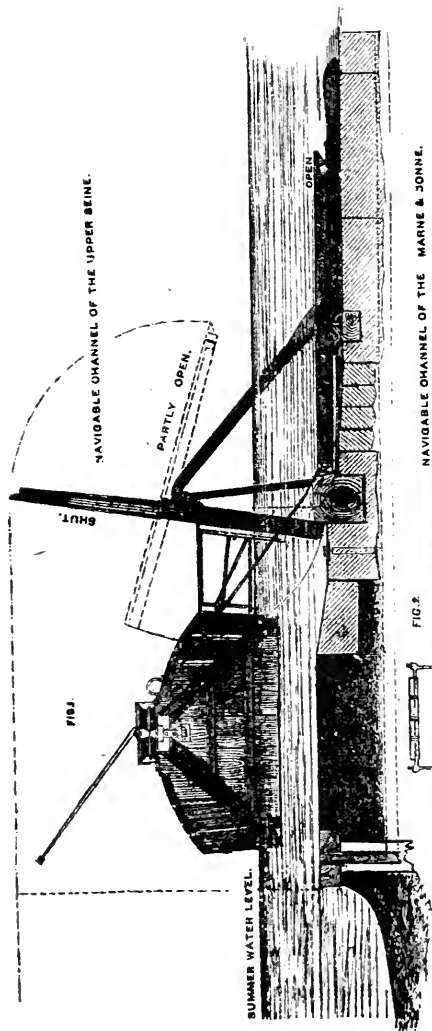
The fact here apparent, that the Ohio, in its exceptionally lowest stage, has four times as much water as the Yonne, and only one fourth as much fall per mile, indicates sufficiently its superior capability of improvement, and to a much greater extent than the French river, which I have chosen at random, from many others, for the illustration.

And what is true of the Ohio in this respect is equally true of the upper Mississippi from St. Paul to St. Louis.

The French devices for closing and opening the navigation passes or chutes, are many of them very ingenious and very complicated. The best in use seems to be the Chanoine system, so called from its inventor.

The following description of one of the movable dams on the upper Seine and Marne, taken from the *London Engineer* of October 22d, 1867, is rather more in detail than that of the report :

"Fig. 1, Pl. 1, shows in section, in line of the stream, the navigable channel of one of the twelve *barrages* of the upper Seine, which have been constructed between Paris and Montereau, each with lock pits of twelve metres wide by 180 metres long in the clear. The river banks above and below are pitch-paved, at a slope of 45 deg, a navigable pass of from 40 to 55 metres wide—one only, at Melun being 65 metres—and a regulating weir of from 60 to 70 metres long. Each navigable pass has from 30 to 42 panels to close it, each being three metres high by 1·20 metres wide, and with a narrow space of 0·10 metres between the vertical edges of each. The other chief dimensions may be had from the figure, which is to scale. The figure shows the application of the flat-bottomed gabbard, which is employed to raise again the *hausse*s into place when the waters have fallen too low for navigation but by lockage. During the period of free navigation the panels are flat down on the bottom, in the position marked by the word "open," the gabbard being moored on the up-stream side, and so that at the curves of its bows it clears the tail end of each panel, the first of three or four of these having been got up into place from the wing-wall or pier, and these being then used by the aid of the crutches seen between the gabbard and the *hausse* as fulcrums to keep off the former; the tail end of each panel in succession is seized by a hooked iron rod, and it is dragged up into the position marked in dotted lines as "partly open." The heavy *cast iron* jointed spur-brace, with the handle-like heavy lower extremities, being connected by the top joint with the panel, comes up along with the latter into its angular position, its lower end dragging along in a race or guide upon the sill provided for it, and when the panel has been brought up a little beyond its proper berth the lower end of the spur-brace drops in behind a catch, which holds it there, and against which it abuts firmly as soon as the tail end of the panel is lowered and begins to receive the pressure of the water, the depth of which at this



season is shallow. In Fig. 1 the water is shown at low summer level, but all this operation can be performed with the water level even above that of the top joints of the *chevalet* and spur brace.

The *chevalet* seen on the flat is an isosceles triangular frame of wrought iron, the lower joints or pivots being at the extremities of the base, at the level of the sill. The top joint is single, but wide in the jaw. Each panel, therefore, when in place is fixed at three points of base, besides its bearing against the sill rabbate at its lower edge. It thus is very stiff and secure.

All the catches by which the spur-braces are held in place are movable, and all connected by a sliding bar lying flat upon the sill, and moving within certain limits end on by the help of a rack at its extremity within the wing-wall or pier, and acted on by spur gear. When, therefore, the waters have risen to such a level that the pass can be opened for navigation these catches are simultaneously released, if desirable, and the entire line of *hausses* cant over at once into the horizontal position upon the top joints of the *chevalets*, and then at once *very quickly subside*, rather than drop down, in the water to their flat position at the bottom. The opening of a navigation pass of above 150 feet wide can thus be effected in *four minutes*. It takes about *an hour to close it again*."

Supplementing this with a portion of M. Cambuzat's description, cited in the report, we learn further, that,

"Each wicket is movable around an axis forming the cap of the horse, which itself turns around its sill, whose journals are held in two boxes fastened in the lower face of the sill of the pass. The wicket, when upright, is inclined at an angle of 15° from the vertical, and laps three inches against the upper face of the sill. The top is even with the surface of the pool. The axis of rotation of the wicket is so placed that the height of the breech above the sill is $5\frac{1}{2}$ of the total height, and consequently that of the chase is $\frac{7}{12}$. The cap of the horse passes through an eye in the head of a prop, whose foot is supported, when the wicket is up, against a cast iron heurter fastened in the sole of the pass. When the wicket is down the prop is retained in a slide, of which the heurter is the head. When it is desired to lower a wicket, the foot of the prop is tripped by a corresponding projection on the tripping rod, which is moved horizontally on the sole by means of a wheel and gearing placed in the pier or in a wall of the lock, for each pass is managed by two tripping-rods, each of which acts upon one-half of the wickets, beginning at the middle of the pass.

"On the other hand, the wickets, when down, are raised by a boat-hook worked from a boat furnished with a windlass and other appliances.

"It is quite evident that the trestles, the props, and the tripping-rods are of wrought iron; the slides and heurters of cast iron."

"This ingenious system," says M. Cambuzat, Chief Engineer *des Ponts et Chaussées*, "was striking in its simplicity, and was accepted at once after the isolated experiments made at a single dam."

The wickets used on the Yonne are from nine to ten feet in height. At certain stages of water they are partially automatic, but are in some cases worked from a boat fitted with machinery for the purpose,

and in others from a foot-bridge, ingeniously constructed so as to be removed when the wickets are down, and replaced when they are to be raised. The boat is shown in Fig. 1, the bridge arrangement, which seems to be preferred, and of which the following is a description, is shown in Fig. 2.

"Each bridge for maneuvering is composed of wrought iron trestles, like the trestles of Poirée dams, movable around a horizontal axis at right angles to the axis of the weir. Each trestle is opposite the middle of a wicket. These trestles are connected at their caps by two clamp-bars, which fix the width of the bridge. Between these bars is a wooden flooring, which is raised 20 inches above the level of the pool. The two clamp bars are the rails upon which rolls the truck that carries the hoisting windlass. Finally, to this windlass reach two chains, one attached to the head of the chase, and the other to the foot of the breech of each wicket. By the help of the windlass, solidly fastened to one or two trestles, and the two chains, every maneuver necessary to regulate the level of the pool—raising, lowering, or swinging the wickets—can be performed without fatigue and without danger. In times of flood the trestles of the foot-bridge fall into a recess nearly on a level with the crown of the weir. The planks, clamp-bars and windlass are put in store. The counter-weights have been removed from the weir-wickets as no longer required."

Our American engineers give full descriptions of the above and many other successful methods in use for closing the navigation passes, accompanied by drawings necessary for their comprehension, all of which will be found to be of great interest to the profession. The limits proper to this paper will only suffice for the one example, and to give the names of the principal methods they have examined. This last is done chiefly to show the great importance which attaches to the subject of river navigation abroad, and to interest others in devising a system more perfect and more suitable to the American rivers.

The following are the methods described in the report:

1. The "bear trap" gate.
2. The wicket used on the Rion.
3. Thenard shutters.
4. Thenard shutters as modified by Fouracres.
5. Poirée needle dam.
6. Combination of the Poirée needle dam and Thenard shutters.
7. Chanoine wickets.
8. Desfontaines wickets.
9. Modified Poirée needle dam.
10. Cuvinot drum-wickets.
11. Crants wicket with pontoon.
12. Carro gates.

13. Girard shutters.
14. S. Petidier's C. E. plan.
15. Capt. J. A. Wood's plan.
16. Col P. J. Schopp's C. E. plan.
17. Brunot's hydraulic gate.

The four last named and the first being American plans.

OBJECTIONS.

The Board, after considering the merits and demerits of the plans, and instituting a comparison between the Seine and the Ohio rivers, greatly favorable to the latter as to its capacity for such works as are proposed, proceed to say :

“One objection to all the French systems, is that the mechanism consists of a great number of parts, all of which must be kept in perfect working order, a thing which is less difficult in France than in this country, because there is a long established and well organized and trained body of inspectors, engineers, and lock and dam-tenders, and assistants, whose lives are devoted to such work, and who are thoroughly capable of attending to it. The lack of such a body in the United States, makes it eminently desirable that all machinery should be of the simplest possible kind, and we believe the plan we recommend has at least this merit.

“Another and more serious objection to the French systems comes from the greater cold of our climate, and the greater danger of injury by ice. The account already given shows that the Seine dams were greatly endangered by an unusual cold of 21°. As this is a very common temperature with us, and as the thermometer is not unfrequently below zero, it is manifest that the danger mentioned would be both more frequently encountered in this country, and more dangerous when encountered, particularly in view of the higher and more sudden floods, and the greater masses of driftwood.” And in another place, “The system now in use on the Yonne and Seine has the advantage of being the gradual growth of long years of study and experiment, and will undoubtedly, at least on the upper Ohio, radically improve the navigation. The question before us, therefore, is whether this system is the best that can be devised for such navigation as is used on the Ohio River, or whether we cannot obtain a method more suited to our wants.”—(Report, page 80.)

AMERICAN METHODS PROPOSED.

The writer of this, in early life, assisted in the surveys for the

Monongahela navigation improvement, and has ever since been a persistent advocate of some radical improvement of the Ohio River.

The diversity of opinion among the engineers who had written upon the subject, as to feasible modes of improvement, and a knowledge of the requirements of the trade and the insuperable objection on the part of those engaged in it, to any plan which would obstruct the river in its navigable stages, led me to the conclusion that no system could be adopted which would not allow a free channel of two or three hundred feet wide in ordinary stages of water. To devise a method of shutting and opening such a sluice-way seemed to be the ultimate and only solution of the problem of an unobjectionable plan, provided it could be done on the principle then in my own mind and since laid down by Hagan, as cited in the report of Messrs. Weitzel & Merrill. About the same time, it became apparent that such a gate or movable dam was imperatively needed on the Monongahela slack water improvement, to permit coal fleets to pass the dams in high water without the delay incident to the ordinary lockage.

Believing that whatever ought to be done, in mechanical engineering, can be done, I set myself to the task of doing it in this case, and in the summer of 1867 devoted several months continuously to the subject. Among the plans devised during this time, several may be worthy of mention.

The first, promising satisfactory results, was a strong gate in a line with the axis of the dam, hinged along the up-stream side to the bottom of the sluice-way, and lying flat upon the bottom. From its down-stream lower edge, iron segments, with cogs on the inner side, projected downwards into wells, their length being something more than the height of the gate when raised. Under the lower edge of the gate, in the angle formed by it and the segments, was a recess containing a continuous shaft with a pinion at each segment working in its cogs. This shaft, driven by an engine from the shore, or a turbine wheel, would raise or lower the gate, or sustain it at any desired height. To the lower edge of the gate, I proposed to hang an apron of wood to protect the segments and shaft when the gate was raised.

This plan was unsatisfactory on account of the amount and character of the machinery, its liability to derangement from ice at certain stages of water, or other causes, and the liability of the wells to become obstructed by sediment, and was abandoned. I may say, however, that it still seems to me practicable and better than any of the French plans in use.

Another expedient, identical with the above, except that, instead

Fig 1

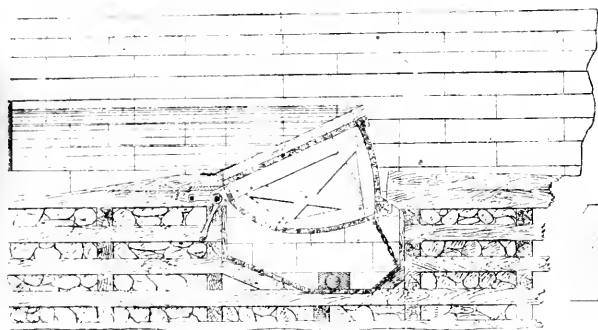


Fig 3.

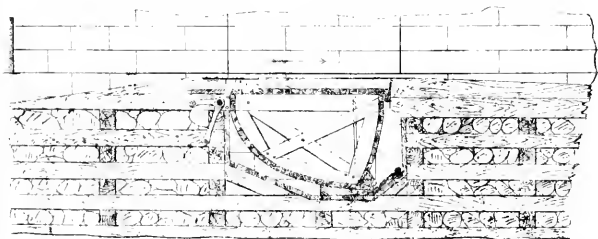
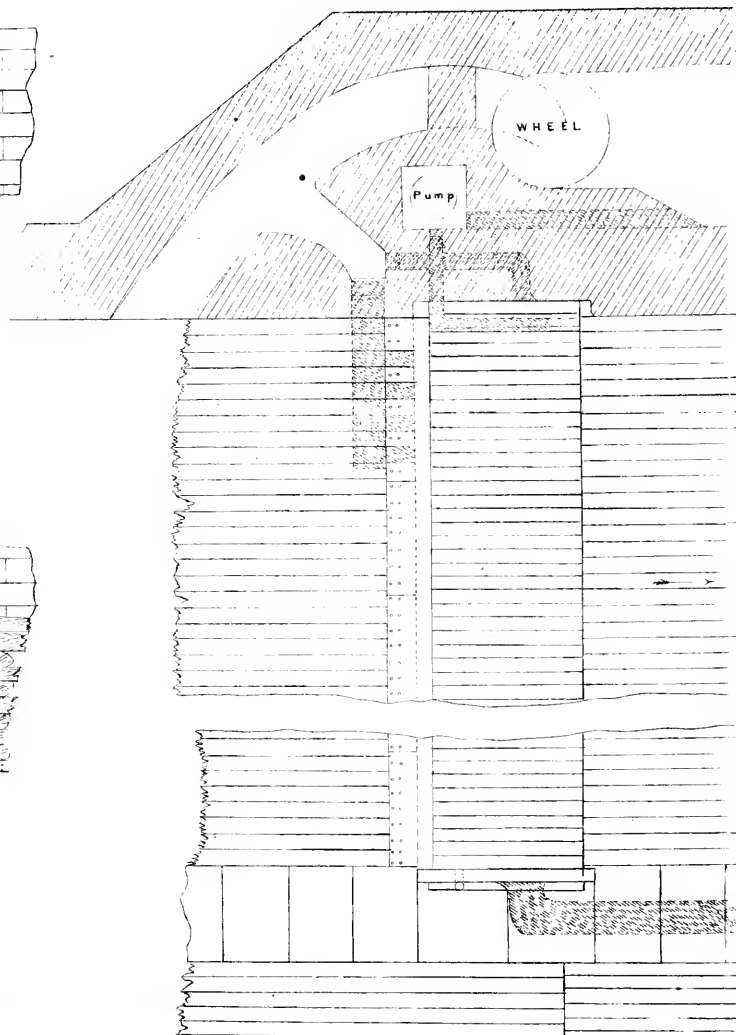
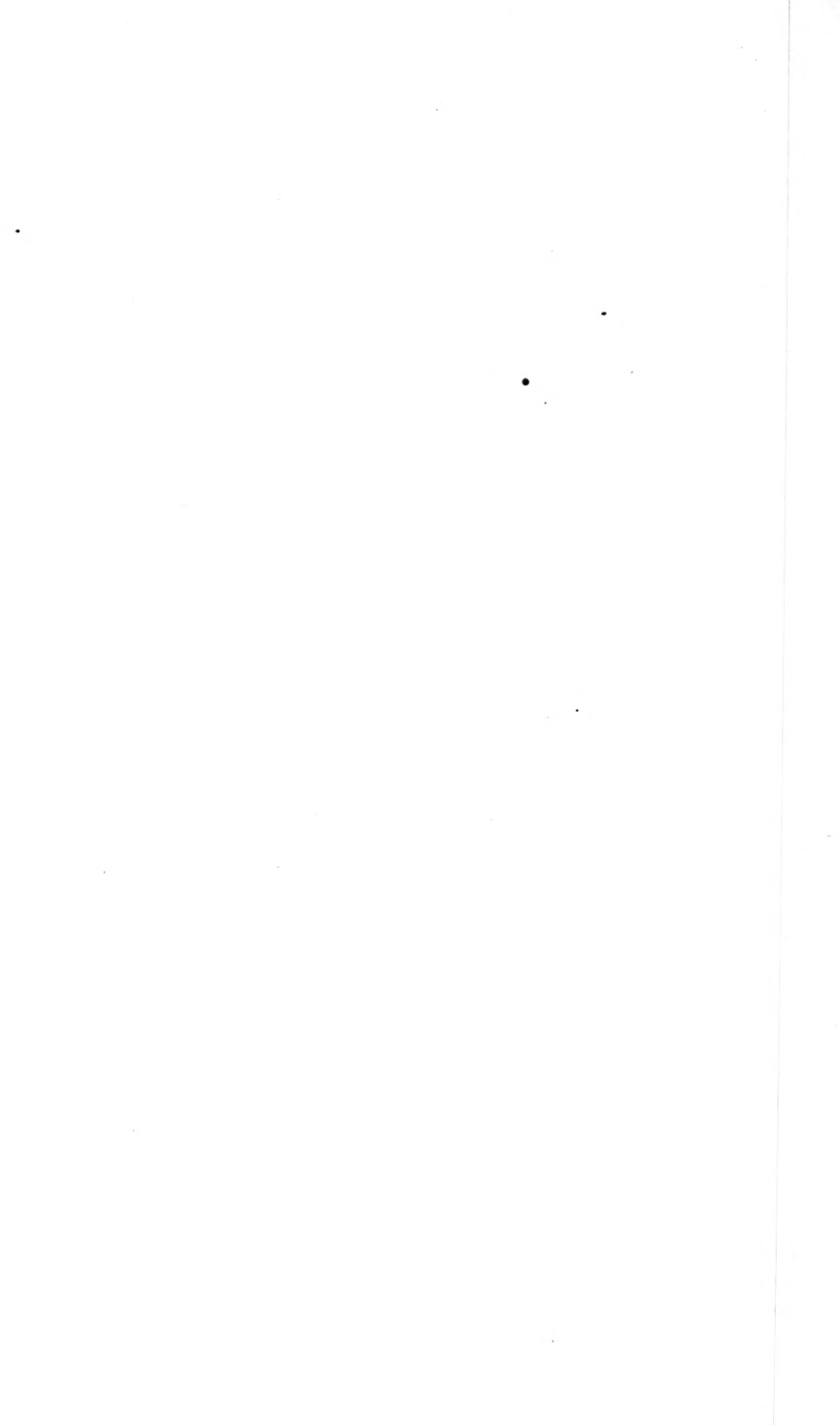


Fig 2





of the segments and shaft, I proposed to place a series of hydraulic jacks in recesses under the lower edge of the gates, the water for raising their pistons to be forced through pipes by an engine upon the shore. This also seemed objectionable from liability to rust, damage, and breakage, and especially from freezing of the water in the pipes and jacks. I learn from the report of Messrs Weitzel & Merrill, that the same method was invented by M. Girard in 1870, for raising Thenard shutters on the Yonne.

Abandoning, then, the machinery idea, I fell upon the device of a strong pontoon, of proper size and depth, and of somewhat greater weight than the water its material would displace. This was to form the gate, working its ends perpendiculary in grooves in the face of the abutments, and relieved by friction rollers, its bottom resting in a recess of sufficient depth to receive the gate or pontoon when sunk. To raise the pontoon, I proposed to pump the water out of it, and to sink it by letting the water in. The plan seemed to have many objections, but was a step in the right direction—that of making the water and the air do the work—and which led to a result which seemed to fully meet the requirements of the case. After the construction of an operating model, the simplicity of the device, and its satisfactory operation, together with the manifest correctness of the principles involved, made it seem impossible that it had not already been somewhere adopted. On this point, an article in the *London Engineer*, of October 25th, 1857, describing the models of the plans for the improvement of river navigation, displayed at the Paris exhibition, was convincing as to its originality.

The following is the description of the plan as given in the report of the Ohio River Board, on page 78.

"The Hon. F. R. Brunot, of Pittsburgh, exhibited to the Board a small model of a floating hydraulic gate, which seems to meet the requirements of the case. Mr. Brunot only presented the model, leaving the completion of the details necessary to put it in practice to be elaborated by us. His system is shown, in section, on Plate 17, Figs. 90, 91, 92.* It consists substantially of a hollow caisson or pontoon, of the length of the desired opening, (see Fig. 92,) and of suitable width and depth. A chamber is excavated in the dam at the place chosen for the gate, and when the latter is in place and lowered, the top of the caisson is even with the floor of the pass, and the passage is free. The up-stream edge of the top of the gate is securely hinged to the up-stream edge of the gate-chamber.

Two methods of manœvering the gate were proposed by the inventor. The first method was to make a connection between the chamber and pool above the dam, so that the hydrostatic pressure of the upper level might raise the

* Plate II, Figs. 1, 2 and 3.

gate. It could only rise in an inclined position, as the upper edge would be held down by the hinges. To lower the gate the connection with the upper pool would be closed and that with the lower one opened, and the gate would fall on the removal of the water pressure. The service of the gate would be simple and inexpensive, as one man only would be required, and his work would be limited to opening and closing valves. * * *

The other method suggested by Mr. Brunot is to fill the gate with water when the chute is to be opened, and to pump the water out when it is to be closed. This will, undoubtedly, secure the desired result beyond any possibility of failure, no matter what may be the difference of level between the two pools, and this is the method which we recommend. The power necessary to do the pumping can always be had from the fall at the dam, and a turbine wheel in a well in the abutment would be the natural method of applying it."

The drawings given are somewhat different in details from the original plan. The terms movable dam, caisson, and gate, are used interchangeably both in the quotations and in the text of this article.

The report presents but two objections to the system, or its mode of operating, both of which refer only to the first named method of working the gates exclusively by means of the hydraulic pressure, and its own floating force, and neither to the mode of operating it by filling and emptying.

In regard to the first objection it remarks, further on :

"We found that by putting a shoulder on the lower edge of the Brunot gate, as shown in figures 90 and 91, we could retain sufficient play and make a tight fit against the chamber wall."

Certainly this obviates the objection if the wall of the chamber is curved to correspond with the lower face of the gate. If the chamber is of masonry, as it ought to be, this may be deemed the better form. In the original model I assumed that the gate would be made of iron, as the best material, and the chamber of wood, for cheapness, and would be rectangular in shape. To obviate the difficulty in question, a lip, intended to be adjustable, is provided at the top of the chamber, and projecting to the face of the gate so as to touch, or nearly touch, it at all points as it moves up or down. There is also a projecting lip on the lower edge of the gate, and one on the upper edge. Thus, when the gate is up, the surfaces make a tight joint, and, when down, the lip at the top serves the same purpose, and when moving, that on the top of the chamber answers the same purpose.

In regard to the other objection, the mode of sinking the gate when the water in the lower level is even with the top of the chamber,

is to let the water into it by opening the valve, when it will immediately sink.

If the gate is made of wood, it should, of course, be permanently ballasted, so as to be somewhat heavier than the specific gravity of its material. The chute being open in the above-named condition of the water no contingency can occur which would require it to be closed until the water, has fallen below the level of the top of the chamber, and as soon as this occurs, the pressure of the higher level of water above the dam becomes available to raise the gate and close the chute in the usual way, the water it contains escaping from its open valve as it rises. This explanation, it will be seen, entirely removes the objection in any case where the top of the chamber, and of the gate when occupying it, makes at a moderate or low stage of water a difference in level between the upper and lower pool, as must necessarily be the case in the proposed chute in Dam No. 1 on the Monongahela River, and in such cases obviates the need of pumping apparatus.

To construct the dams and chutes upon the Ohio River on the same plan of creating so considerable a difference between the level in the upper and lower pools, would leave a free downward navigation as long as the water is deep enough in the chute to permit, but probably would compel the up-stream craft to pass through the locks, even at ordinary stages of water. This does not accord with my idea of the best improvement, which is to leave the river as available as now, for both upward and downward navigation, as long as there is sufficient water in the chutes for the draft of steamers. When too scant for this the movable dam would be raised and the pools filled, thus creating a lock and dam navigation for the upward trade, and continuing the downward navigation as before by dropping the gates for the passage of boats or fleets, and immediately raising them after each passage.

On this plan the bottom of the chutes must more nearly approximate to the bottom of the river, and the dam would require to be raised in slack water, or, at best, in only a rapid current, which would afford no power adequate to the purpose. This led me to adopt the method of filling the movable dam to sink it, and pumping out to raise it.

I fully agree with the Board that this method is unobjectionable in its operation and effectiveness, and cannot fail of success. I consider their mode of applying the pump admirable, although hardly so good as my own. I proposed to fix at the end of the axis of the gate a pipe corresponding therewith and extending by an elbow to the

bottom of the gate. This pipe, which moves with the axis of the gate, extends into the abutment, and connects with the suction pipe by the ordinary plan of hose coupling. The same pipe to be used for filling the gate by admitting the water through a perpendicular to the suction pipe near the coupling, and closed by a valve. The following is the method of application proposed by the Board :

“There are two methods of filling the gate—by opening the valves in the top of the gate itself, or by opening a pipe which communicates with the interior of the gate. As the gate rises and falls around a horizontal axis, there is some difficulty in devising an apparatus to move these valves at all times which shall itself be sheltered from floating bodies. Moreover, valves in the top of the gate are liable to injury, and they weaken the gate where it ought to be strongest. For these reasons we propose to permit water to enter by a pipe under the platform of the chute, which shall connect with the interior of the gate by several branches of flexible pipe entering just below the hinges. The main pipe will be controlled by a valve worked from the abutment, as shown in Fig. 92. It is calculated that a two-foot pipe will fill the experimental gate, 100 feet in length, in 2 minutes, which is, probably, quick enough. To empty the gate a centrifugal pump is used, whose suction pipe has a flexible length to connect it with a pipe extending to the bottom of the gate. This pump will be set in motion by a turbine wheel. The necessary power to drive this pump was calculated by assuming five minutes as the time for the work, and taking the capacity of the experimental gate as 5,000 cubic feet and the lift as six feet. We, therefore, have a quantity of work of 375,000 foot-pounds per minute, or 11.4 horse-power. The effective work of pumps is given by Bourne as ranging from 30 to 65 per cent. of the power applied to them, and, therefore, with an assumed efficiency of 38 per cent. we find that we require 30 horse-power to work this pump.

To get the size of turbine necessary to develop this effective power we use Francis's formula.

$$D = 4.85 \sqrt{\frac{P}{h \sqrt{h}}}$$

in which $P = 30$, the effective horse-power, and

$h = 6$, the assumed head of water. We, therefore, find—

$$D = 6.93 \text{ feet.}$$

The amount of water necessary to supply this wheel is found by the formula also given by Mr. Francis :

$$Q = 0.5 D^2 \sqrt{h}$$

Whence we find—

$$Q = 58.8 \text{ feet per second.}$$

To supply this amount of water without great velocity, and, therefore, without sensible loss of head, the water in the channel leading to the turbine should have a velocity of not more than 3 feet per second; and, therefore, the cross-section of the channel should be about 20 square feet. We have, therefore, taken

a width of four feet and a depth of five. The positions of the pump and turbine are shown in Fig. 92.

It is important to have some arrangement for the automatic filling of the gate, should a sudden flood come in the night, or when the gate-tender was absent or negligent. This is provided for by a stationary pipe at the far end of the gate, which is sheltered from floating bodies by the recess at that end of the chamber. The height of this pipe is such that when there is a greater depth in the chute than seven feet, the water overflows into the gate. This pipe also answers as an air-pipe during the maneuvering of the gate.

The most important navigation on the upper part of the Ohio River is the transport of coal, and as this transport is always down stream, and as the ponderous coal-fleets are not easily checked or stopped, it is very desirable that the process of lowering the gate and opening the pass should be very expeditious, while there need be no great hurry in raising the gate. The system proposed answers these ends perfectly. One man can maneuver the gate, and it can be filled with any desired rapidity. If the two-foot pipe should not do the work fast enough, there is no difficulty whatever in using one of greater diameter. After the fleet has passed, the attendant has only to open the gate of the turbine, and in a few minutes the pass is closed. It seems hardly possible to devise a system that could promise better results.

In order to scour out any sediment that may accumulate in the chamber, a culvert is made at the far end, and inlet pipes at the abutment. As this operation would seldom be necessary. (possibly once a year,) it is believed that the management of the valve at the far end would offer no practical difficulty. Excepting this one valve, all the mechanism is on the abutment, and is, therefore, always accessible."

Although the mode of operating it by filling and pumping out the gate is unobjectionable in its working, there is a third plan, which, if a pump is used, may be found to be preferable, viz., to *pump in air* through the hollow axis, which will by its pressure displace the water, a valve in the end at the lowest point being opened for its escape.

Nevertheless, a pump of any sort, with its propelling power, is additional machinery and more liable to breakage or disorder than a simple valve or wicket, and for this reason I devised a plan to work the gate effectively without that aid.

It is proper in this connection to say that having had but a short interview with the Board at the time my model was examined, nearly a year ago, and not being aware of their continued and laborious experimental investigation of the subject until after the publication of the present report, neither this plan or that above-mentioned has been submitted to the Board.

It is evident that the gate will not be wanted, nor can any necessity occur for raising it until the water in the natural channel and in the sluice, falls to a depth of say five or eight feet, or whatever may

be assumed as the minimum for navigation. When this point is reached and the gate is *once* raised, the dam it forms will create a head which will give the power to raise it again as often as it may be dropped for the passage of craft. In the process of rising, it would itself create the power to continue, and accelerate the upward movement.

I propose to place a tank or reservoir either in the abutment or on shore, which will fill in the flow of high or ordinary stages of water, and by closing an automatic valve retain the water until needed to raise the gate. This would be done simply by opening the valve of a duct connecting the reservoir with the chamber, and opening the valve in the end of the gate to permit the escape of its contents.

This device, it seems to me, fully overcomes the objection suggested, and renders the pumping arrangement unnecessary.

But even this addition is not necessary to properly work the proposed movable dam or gate on the Monongahela; nor will it be necessary upon the Ohio River, if the level of the bottom of the chutes shall be placed at any similar height above the bottom of the stream. In any event, the movable dams suitable for the Ohio need only differ from that required at Dam No. 1, on the Monongahela River, in dimensions, and that can be increased to scale in all the parts, as far as may be desired. I therefore proceed to describe the

PROPOSED PLAN FOR A CHUTE AND MOVABLE DAM ON THE MONONGAHELA RIVER.

It consists of the following parts: The chamber of masonry A, Pl. III, 104 feet long, 12' 3'' wide, 4' 6'' deep, the top being 4' below the comb of the permanent dam; 4 feet of the length of the chamber being in a recess in the abutment C, Fig. 4, is 1' 6'' deeper than the other part, to permit the working of the down stream wickets. Forming so much of the top of each wall is a timber D and D¹; that on the upper wall to be formed on its corner into a hollow quoin for the heel of the movable dam or gate, and that on the lower wall shaped to form a stop and rest, and a tight joint when the gate is either up or down, and a joint with the curved face of the gate when moving. The timbers to be firmly anchored beneath the masonry by bolts.

The movable dam or gate, B, made of iron, 100 feet long, 4' 3'' deep outside, 12' 6'' wide on top, including the heel or hinge, which is 6'' in diameter. The heel is held or hinged with strong iron straps, 20 feet apart, and securely fastened. The down stream face is, in its

Fig 1

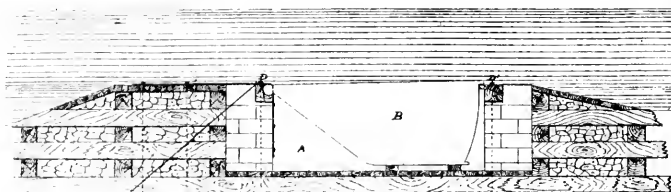
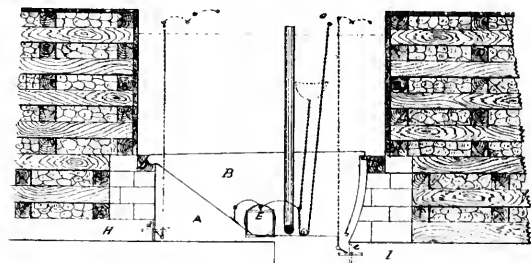


Fig 3



PLAN OF
MOVABLE DAM

FOR THE

MONONGAHELA RIVER.

Fig 2

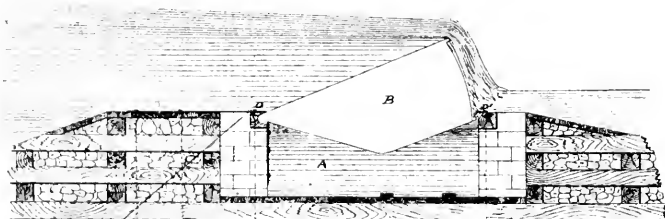
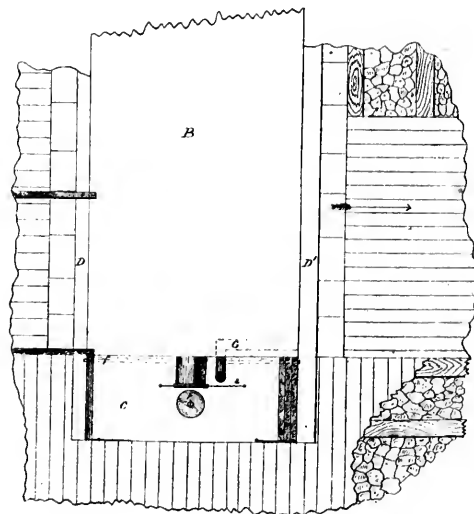


Fig 4





perpendicular direction, a segment drawn from the axis as its centre. The bottom, and back, or up stream side, is extended beyond the end of the gate into the recess of the abutment, 4 feet, to the wall. The top and front sides terminate with the end, at the face of the abutment. This projection forms a floor, which divides the recess from the part of the chamber beneath it. In this floor is a man-hole, E, for access to the chamber.

In the end of the gate, projecting into the recess, and at the point which will be lowest when the gate is up, is a pipe, F, closed at its outer end by a slide valve, and large enough to serve also as a man-hole.

Attached to the top of the valve is a lever, *a*, at the end of which is a chain holding a float, which will draw upon the chain and partly open the valve whenever the water in the river rises to a height of three feet above the comb of the dam. At the same time, a similar float attached to its lever will open the lower wicket, and permit the water to escape from the chamber.

This arrangement is for the purpose of sinking the gate automatically, in case of sudden floods at night, or in the absence of an attendant.

As it is desirable to admit no more water than is necessary to sink the gate, another chain, *o*, attached to the end of the lever *a*, passes down through a pulley fixed on the projecting floor, and thence to the top of the abutment, where it is fastened. This chain is slack—the slack being equal to the difference between the sweep of the lever and the perpendicular fall of the gate at the point of attachment. When the gate sinks it draws down the lever and closes the valve.

The purpose of the above devices, viz., the admission of water and stopping it when enough has entered, may be also effected by a stand pipe, rising from the top of the man-hole pipe to the proper height, and with a valve on the top, the normal condition of which would be open. A chain attached to the valve passes down through the pipe, around a pulley at its angle, and, entering the gate, is there fast to a float, which, when the desired quantity of water has been admitted, draws upon the chain and closes the valve at the top of the pipe.

There is a stand-pipe, G, for admission and egress of air, which enters the end of the gate by the side of the water pipe, and by an elbow and arm reaches to near the top of the gate inside. Its outside arm rises to the top of the abutment.

There are ducts, H and I, leading from the end of the chamber be-

neath the gate to the upper and lower pools, respectively, closed by wickets, *d* and *e*.

At the further end of the chamber there is a communication with the lower pool, closed by wickets.

The recess in the abutment is separated from the chute by a partition, *f*, which extends two inches below the top of the gate when it is down. The down stream end of the recess is curved from the bottom to the top of the chamber, so that the projecting bottom of the gate will nearly touch at all points, as it rises or falls.

The wickets, gate valve, stand-pipe, levers, floats and chains are all within the recess, and worked from the top of the abutment. They are protected from the drift of submerging floods by an iron trap door, which is closed by hand, or automatically by the sinking of the gate.

THE PRINCIPLES AND MODE OF OPERATING.

The forces brought into requisition are—

The floating power of the hollow water-tight caisson or gate.

The hydrostatic pressure due to the difference in level between the upper and lower pools.

The support given to the gate at every point by the inelastic body of water confined in the chamber beneath it, and which is approximately equal to a solid foundation.

The gravity of water introduced to sink the gate in certain contingencies.

The mode of operating is—

1. The gate being down, and the pass or chute open, it is raised, and the pass closed, by shutting the down-stream wicket, and opening that which connects with the upper pool.

2. The gate being up, it is dropped by shutting the up-stream wicket and opening that which connects with the lower pool.

3. If the back water is above the top of the chamber, the valve in the gate is opened, and the down-stream wicket at the same time, and the gate will sink.

This contingency can only occur in extreme high water, and when it occurs the gate will not be needed until the water falls again below the chamber. The gate will then rise by the adjustment of the wickets, and opening the valve for the escape of its contents.

When sediment accumulates in the bottom of the chamber, the wicket communicating with the upper pool, and the wicket at the further end of the chamber, connecting with the lower pool, are both

opened, and the strong current through the length of the chamber will wash it out.

OTHER CONSIDERATIONS.

The slope of the upper side of Dam No. 1, on the Monongahela River, is 3 to 1. I have, therefore, made the slope of the movable dam to correspond, and this fixes its width.

The shape of the bottom may be varied. I have chosen that shown in the drawing as being simple and of easy construction, and as dividing the upward pressure of the gate when raised nearly equally between the heel and toe of the gate. The amount of displacement and best form of the bottom is a matter of easy calculation, depending in part upon the specific gravity of the material used. It should be such that if the gate were lying unhinged in open water, the heel and toe would rest a little above the surface. It is manifest that with several feet of water above the top of the gate its tendency to rise will be vastly increased both by the enlarged displacement and the added pressure beneath. Hence the necessity of strong fastenings for both the quoin and toe timbers and the hinge straps. The resistance to be provided against by these, at whatever stage of water, is a matter of calculation.

The rectangular form for the chamber is preferred because it is easy of construction, and gives ample room beneath the gate for examination or repairs of the bottom. This can be done in low water by placing temporary props under the lip to hold it in its raised position, and letting out the water from beneath it.

In regard, further, to the application of this plan to the Ohio River, should it prove successful upon the Monongahela, it will require very little modification. Although the Board of Engineers assume 200 feet as the width of chute they propose, there is nothing in the plan of the gate which will necessarily limit it to that length. Its ample interior gives room for any degree of strength needed, and its principles of support and operation will apply to any length.

A caisson or craft of similar dimensions, resting in open water, could hardly be prevented from hogging. In this case the gate when up is sustained in its whole length by its quoin resting on the wall, and by the *equal* upward pressure at all points of the confined body of water upon which it rests. *No amount of load can force it down unless the water can escape from the chamber.* When it is down, it rests on the quoin, the toe projection, and the sills under the bottom.

The time required for the raising and dropping the gate is controlled by the size of the wickets and ducts; and by placing these, as they should be placed in a long gate, at several points, *it may be easily made to drop or rise in one minute.* The wickets would be the common lock-valve wickets, working on perpendicular centres, located at intervals along the face in both sides of the chamber, those on each side connected by short levers to a horizontal rod extending along the inside of the chamber to the recess in the abutment, and there worked by a common upright straight lever, which would open or shut them all by one motion of the hand.

CONCLUSION.

Whilst the Board of United States Engineers in their report have expressed, almost as strongly as the inventor, their confidence in the success of the plan they recommend, and pointed out very clearly its superiority to any of the foreign systems in use, they nevertheless very judiciously and properly confine themselves to a recommendation that it should be tested. They remark:

“Should the system which we recommend for trial be adopted, we will find ourselves provided with a navigation that differs in many particulars from that used in France. In the latter country, as soon as the natural depth in the river is less than 5 feet, the passes are closed, and all navigation in either direction is carried on through the locks. On our system, if we can get a gate, as we think we can, that can be opened in two minutes, and closed in five, it will be quite practicable to keep up an intermittent down-stream navigation through the pass throughout almost the whole year, as the opening of the gate for not to exceed ten minutes at a time, which, allowing for diminished discharge while being opened and shut, will make the total expenditure of water about equal to a full opening of the chute for five minutes, will probably not injuriously lower the level of the upper pool. We would thus have a natural down-stream navigation throughout almost the entire year, which would be an immense advantage, since our heavy products, such as coal and manufactured iron, all go down the river. To counterbalance this advantage, we would have the disadvantage of forcing all up-stream navigation, except in very high water, to pass through the locks. The latter would have to be higher than the French locks, and our expenditures for masonry and timber for the dam, and inclined plane, would much exceed theirs. To counterbalance this, we have simpler constructions, less complicated mechanism (which is both very costly, and must be carefully watched and kept in order), and probably less expense for attendance. It is, therefore, mainly on account of the special character of our climate, and of our navigation, that we recommend that a system differing from those used in France be first tested, in preference to copying what are successful in their native country, but which might not work so well here. We wish it to be specially understood that, while we have attempted to collect all available information on this subject, we do not presume to decide the question now, but limit our-

selves to recommending a preliminary experiment. * * * * *
 * * * * * If it is a success, there
 need no longer be any difference of opinion about the radical improvement of
 that river. As such vast interests depend upon this trial, they would most
 urgently press its importance upon Congress."

The report concludes with the statement that the Monongahela Navigation Company, being desirous to have a navigation-pass constructed in Dam No. 1, through Hon. J. K. Moorhead, President of the Company, has offered that work for the experiment, agreeing to pay one-half the cost, "we would, therefore," they say, "urgently recommend the appropriation by Congress of \$40,000 for the purpose of experimenting with a navigable chute, to be opened and closed by a hydraulic gate, in one of the dams of the Monongahela Navigation Company," &c.

Undoubtedly an actual test, upon an adequate scale, is the only possible mode of reaching a safe conclusion, and the test must inevitably be made, sooner or later, by the General Government. Why not make it now?

It can be shown that, aside from the great questions of cheapness of transportation, the increased cost of fuel to the West and South owing to the fitful and precarious character of the present navigation, and other considerations, making up an aggregate of transcendent importance, the loss of interest on capital invested in craft and their burdens, whilst idly waiting for a movement of the waters, is annually greater than the appropriation the Ohio River engineers ask for their experiment. A noble river, which reaches by steam navigation the States of New York, Pennsylvania, Ohio, Virginia, Kentucky, Tennessee, Indiana, Illinois and Missouri, and at its mouth connects with the Mississippi and its tributaries, reaching by a similar navigation the States of Mississippi, Louisiana, Arkansas, Iowa, Wisconsin, Kansas, Nebraska, and the Territories of Dakota and Montana, inhabited in all by more than twenty-five millions of the people; a navigation which washes a shore line greater in length than the Atlantic, Pacific and Gulf coasts combined, and with a greater number of harbors, is certainly of national importance; and Congress cannot much longer delay to take the necessary steps towards such a radical improvement as will render its navigation perennial.

Pittsburgh, April 4th, 1874.

Chemistry, Physics, Technology, etc.

SECOND CHEMICAL AND SANITARY REPORT UPON THE WATER SUPPLY OF THE CITIES OF NEWARK AND JERSEY CITY.

BY PROFESSOR HENRY WURTZ.

(Corrected and prepared for this Journal by the Author.)

HOBOKEN, October 1st, 1873.

To the Joint Commission of the Jersey City Board of Public Works, and the Newark Aqueduct Board:

Gentlemen:—On the first day of July last, I first received from your Honorable Commission, by the hands of His Honor, Mayor Ricord, of Newark, definite written instructions, to renew and continue the investigations begun by me in October, 1872, by order of the Board of Public Works of Jersey City (of which a report was rendered by me under date of March 1, 1873, to that Board), upon the pollution of the Passaic River by sewage.

I was instructed to make chemical examination, also, of the water conveyed by the Morris Canal, regarding its availability as a source of pure water supply to your two cities.

Much traveling had to be done by me in collecting samples, and in examining at different times the condition of the water in the river and the canal. By dint of unremitting confinement to my laboratory in the intervals, however, a great number of analytical determinations have been accomplished, leading to results of the highest interest, which include, I believe, full chemical data for the settlement of the important questions pending—questions which intimately involve the future welfare of your cities for all time.

Field-Work and Collection of Samples.—On July 8th and 9th an examination was made of the upper Rockaway, and of the Canal from Denville through Rockaway and Dover, and up to the Hopatcong feeder. July 23d the lower Passaic was carefully reconnoitered from Newark up to Passaic, and four samples taken, at both extreme high and extreme low tide, at the Newark and Jersey City pumping-stations in Belleville. July 24th I drove up along the river and canal very nearly to Beavertown, and back again, the waters being carefully inspected and examined at various points, including the canal feeder across Pompton Plains, which was followed on foot for a con-

siderable distance. Samples were secured of the Passaic above the falls, of the Pompton feeder, and of the canal near Beavertown. The samples taken July 23d and 24th are of especial value and importance, as the river was then at about an *average* height, and not in the low state it usually assumes during that month. It will be recollected that the month of June of this year was exceptional, being the *very driest*, and one of the hottest Junes on record, and that this drought continued till somewhere about the middle of July, but that during the latter half of July considerable rain fell.

July 28th an expedition was made up along the Rockaway River and Canal, from Rockaway to the foot of Lake Hopatcong, examining particularly the summit level, the Hopatcong feeder, and the lake itself, the shores of which were followed round on foot for a considerable distance. Samples were taken from the margin of the lake itself, that is, from the surface (there had been a very heavy rain during the previous night which had raised the level of the lake two inches), and from the outlet; the latter representing water emitted through a gate some ten feet below the surface of the lake. It was thought undesirable to take a sample from the feeder itself, as this *might* have shown fecal and urinary contaminations from the horses and boats occasionally traversing it at present. Should the feeder be closed to navigation, it will, of course, convey the water of the lake without such contamination, or just as the analysis represents it.

On the 13th of August, Messrs. Bailey and Hartman* kindly collected for me a sample of the water from the channel of the river, in Newark, at extreme high tide, off the Bridge street bridge. On the same day these gentlemen procured for me samples of the water from three of the public street *pumps* in Newark, which I have since examined, as set forth below.

During the month of August several successive appointments were made to make another expedition to examine the lower Passaic together, minutely, from Newark up to and through Paterson, as well as to collect samples of the August waters for analysis. These were all baffled, however, by the continuous rains, which kept the river somewhat flooded, even during that month, besides rendering exploring impracticable.

August 20th, another expedition was made to procure samples of the water in the city of Newark. Samples were taken—one from the

* Mr. Bailey is the Chief Engineer of the Newark Aqueduct Board; Mr. Hartman being an assistant of my own.—H. W.

channel off Madison street (below the discharge of the sewers), just before the time of ebb; a second from just above the opening of the Branch-brook sewer (the most northerly sewer), just after the beginning of rise of tide.

August 22d a sample was procured of the water of the Atlantic ocean, in which I desired to make a determination of nitric acid, for comparison.

Finally, another opportunity was had by me to inspect the condition of the river and canal at some points, during a journey along their line on September 22d.

Samples of Croton water were also obtained for comparative examination as regards chlorine and nitric acid.

The *preservation* of these samples of water during the summer heat in an unaltered condition being a problematical matter, the device was resorted to of keeping them in an ice-box provided specially for the purpose.

All the results presented in this report were, as is habitual with me, obtained with my own hands, and by my own labor exclusively. The analysis were confined to the determination of the following—being those ingredients which bear, or are believed bear, witness regarding sewage pollution:—

The total solid constituents.

The loss on incineration, and the ash.

The nitric acid and nitrates.

The combined ammonia (including that of urea).

The ammonia derived from proteine bodies.

The chlorine and common salt.

In order to secure uniformity for chemical comparison, it was obviously necessary to make all these determinations upon the waters after settling perfectly clear, that is, to confine myself to the ingredients in actual solution.

For comparison, I add here another table, in which the results reported last March, upon the waters of October and December of last year, are arranged in a similar way.*

* Last year means 1872. See *Journal of the Franklin Institute* for July, 1873.
—ED. JOUR. FRANKLIN INST.

TABLE II.

Number.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
	SAMPLES.	Total Solids.	Loss on Incineration.	Ash.	Nitric Acid.	Saltpetre, equivalent to the Nitric Acid.	Combined Ammonia.	Urea, equivalent to the Combined Ammonia.	Ammonia, derived from matters of Animal origin.	"Albumenoids" (by Wanklyn & Chapman's hypothesis)	Chlorine.	Common Salt, equivalent to the Chlorine.
JERSEY CITY WATER WORKS.												
21	Low tide—Oct. 10, 1872.....	5.190	1.836	3.354	0.193	0.361	0.010	0.018	0.004	0.044	0.151	0.248
22	High tide—Oct. 10, 1872.....	4.783	1.896	2.887	0.338	0.632	0.004	0.007	0.011	0.107	0.292	0.482
23	Rec'g reservoir, Oct. 10, 1872	4.767	1.442	3.325	0.241	0.451	0.009	0.016	0.008	0.081	0.216	0.356
HOBOKEN HYDRANT.												
24	Mean of Dec. '72 and Jan. '73..	4.107	1.198	2.909	0.280	0.524	0.005	0.009	0.005	0.047	0.152	0.251

DISCUSSION OF THE ANALYSES.

1. *The Lower Passaic (below the Falls).*—The analyses to be immediately considered under this head are numbered 1, 2, 3, 4, 10, 11, 12, 16, 17, 21, 22, 23 and 24.

The Solid Constituents.—A number of curious facts are developed by an attentive study of the figures in columns 2, 3 and 4. But few can occupy space. In the first place, considering the ash, or fixed mineral matters—(column 4), it will be seen that there was more in solution during the rainy period—(Nos. 1, 2, 3, 4, 11), than during the drought—(No 10). The mean of 1, 2, 3, 4 and 11 is 4.717; No. 10 being but 3.086. Next, the high tide waters contain more mineral matter than the low tide; the mean of two results, closely concurrent in each case, being in the high tide—Nos. 1 and 3, 5.402, and in the low tide—(Nos. 2 and 4), 4.291. This difference cannot be due to mixture of the upward tide with brackish water, for the chlorine—(column 11), would then show it, but would seem clearly due to the mineral matters imparted in solution by the Newark sewage. Complete analyses only could show, fully, the nature of these changes.

The low tide waters contain much more volatile and combustible matter than the high tide, and, during the flooded month—August (see No. 11), this underwent a further large increase. The substance brought in by the floods is, doubtless, chiefly vegetable or peaty matter. It will be observed that August 9th the ash was rather less than in July, though more than during the drought in June.

Nitric Acid and Nitrates.—Here the writer's results, at first, somewhat puzzled him. He had adopted, in the former report, the views

of that school of chemists which deems the presence of *nitrates* to be the most valuable index to sewage contamination; certainly, in cases such as this, where no geological formation, liable to contain nitrates, is concerned. As an example of the views of this school, Dr. Frankland said some four years since that, after the most diligent search, he had "failed to discover the slightest evidence of the formation of nitrates from vegetable matters. Whenever nitrates are found in England or abroad, they can be traced generally, with the utmost ease, to animal sources, and whenever such sources are absent, nitrates are absent, too, although considerable quantities of combined nitrogen may be present. It would be a wonderful thing if the water of the chalk wells did not frequently contain nitrates, considering that it is derived by percolation from the sewage and manure-stained soil above."

A little consideration, however, and especially a little exploration along the banks of the lower Passaic, during the heats of summer, suggests most conclusively that there are, with us, very potent disturbing influences, which, *in the summer season*, practically interfere with the chemical investigation of the nitrate question. Between Newark and Belleville the river, for long distances, was almost a continuous thicket or plantation of vigorous water-weeds, and the tide, while rising, was sifted or filtered through this immense mass of growing vegetable matter. It is no wonder, then, considering the well-known power of vegetation to absorb and assimilate nitrates and ammoniacal compounds, that, in summer at least, the proportion of these that would be expected to result from the drainage of Newark, should be disturbed. Hence it happened that the proportion of nitrates found in the upward and downward flows of July 23d, at the Jersey City Water Works at Belleville, was found the same. This growth of weeds extended all along the channel, even above the Newark Water Works. Hence the further loss of one-tenth of a grain per gallon of nitric acid during the flow of but one mile from the Jersey City up to the Newark Works.

In the fall or winter, however, after this vegetative process has ceased, the nitrate test for previous sewage contamination may doubtless be made use of—at least as a comparative test—though some further and still more remarkable facts yet remain to be set forth on this subject.

Combined Ammonia (including Urea).—The proportion of this found in these Passaic waters, above Newark, is mostly so trifling

that little can be deduced from it with certainty. In samples 16 and 17, however, which were procured with the express object of ascertaining the immediate effect of the fresh sewage of Newark (so far as might be), the figures mount up to something appreciable. In No. 16, which was taken just before the turn of the tide, at ebb, the amount of urea indicated is one part in 500,000. The amount of average *urine* itself indicated here is about three and one-half grains per gallon. It would appear, from the experience of many analysts, that during the warm season urea is so changeable and evanescent a thing, in river water, that it must be caught immediately, to be detected; and it is, therefore, probable that the amount of urine above estimated, $3\frac{1}{2}$ grains per gallon, is much too low.* It must be pointed out, also, that in the low tide water at the Newark Works (No. 2), the indications of urea were unmistakeable, being doubtless due to the drainage from Passaic and Rutherford Park, above.

Animal Matters.—It is now well admitted as proved, that the ammonia obtained by distilling with Wanklyn and Chapman's reagent (permanganate and caustic potash) is of animal origin, or at least from derivatives of proteine compounds, which are usually susceptible of putrefaction. It certainly furnishes us the most reliable text for putrefiable matter in water that we have up to the present time. W. & C. believed, from their experiments, that such ammonia could be considered as indicating as much as ten times its weight of proteine matters. This my own experiments furnish me strong reason to think to be (as a universal rule) an over-estimate; but I adopt their hypothesis in setting forth my results, premising that I deem it merely a hypothesis. In any case, the results have high value, if only as comparative, and not absolutely positive. It will be observed that the amount of this "albuminoid ammonia," as it is called in the books, in the tide just after the turn from ebb to flow in Newark, August 20, was nearly three-tenths of a grain to the gallon, indicating, according to the hypothesis, nearly three grains of albuminous matter, or say twelve grains of rotten egg to the gallon, from Newark 'sewage. This would be equal to one rotten egg in 66 gallons—instead

* A solution of urea in water decomposes spontaneously into carbonate of ammonia, which is very volatile and escapes quickly. One equivalent of urea and four equivalents of water are resolvable exactly into two equivalents of neutral carbonate of ammonia. Presence of animal matters, acting as ferment, rapidly produces this change, and probably it is quicker also in the presence of basic carbonates.

of 200 gallons, as estimated in my report of March last; without having then made actual analyses of the water in Newark. It will also be observed (on referring to No. 3), that when the up-tide flow reaches the Jersey City Works the proportion has fallen to just one-tenth of this amount, and when the tide has risen to the Newark Works, one mile more, there is *none* appreciable. [It must be recollected, however, that there is here an element of uncertainty, inasmuch as the Newark city sample referred to was taken at a different season from the others].

Again, going down stream, it will be observed that the falling tide carries with it from the towns above, to the Newark Works, nearly one grain of this class of compounds, which, while flowing along the mile reach to the Jersey City Works through and over beds of weeds, dwindles down to little over one-tenth grain. It must be remarked also that this part of the stream absolutely *swarms* with *fish*, which of course devour all animal matter in the water that is amenable to their digestion.

Unfortunately, however, there is evidence, even in this brief table of analyses, that all these influences, the atmospheric oxidation, the plant-digestion and the fish-digestion, acting together, cannot be relied on at all seasons and under all circumstances—or, it may be, at all hours of the day, and, especially, *the night*—to remove the whole of these dangerous putrefiable substances. Nos. 10 and 11, but particularly the latter, show this without the possibility of doubt. These two samples represent average water (high and low tide mixed) pumped up at the Jersey City Works, in two very different conditions of the river, one during drought and the other during flood. The sample of August 9 indicates an amount of “albuminoid” ammonia which I much regret to see, as it suggests that, under still more unfavorable conditions, which doubtless often exist (this having been a mere random hit), the proportion that gets into the reservoirs may be far larger.

The large proportion of “albuminoid”—(0.875), brought down to the Newark works by the down flow—(No. 2), indicates the probability that, at points further up stream, still more would be found, and therefore appears to tell strongly against the somewhat hasty suggestion thrown out in my report of March last, to bring the water by canals to the pumping stations, from points higher up stream, in order to get further away from the Newark sewers. We should thus be only getting nearer to the sewers that come in above. It

must be remembered that the volume of the mean velocity of the down-flow must always be greater than that of the up-flow, and this is particularly so in times of flood. One result of these analyses must then be the definite abandonment on my part of the recommendation to take the water from higher up the river.*

I would suggest, indeed, to your Honorable Commission, that the original location of your two pumping stations just where they are, was, in some sort, a providential circumstance. They *now* lie, however, in a critical location between Scylla and Charybdis, and must, I should think, before long, be swallowed up (metaphorically speaking) by the one or the other of these monsters.

The Chlorine and Common Salt.—These ingredients are regarded by many, as furnishing ordinarily more reliable evidence than any others, of previous contamination of water by sewage. As the evidence from nitrates fails us, in a measure, during the summer season, at least, as a *comparative* test, I turn with much interest to the study of the chlorine determinations. They present points of value, and concur generally very well with the results of the Wanklyn and Chapman method; but unfortunately, in this part of the river, there is so much uncertainty with regard to possible admixture with the salt water that comes up to, or even above, Newark at extreme high tide, that I do not feel much confidence in these chlorine figures. The sample of high tide in Newark (No. 12), was procured partly with a view to determine the amount of salt water that makes its way up to Newark at high tides. The result was, that *this* high water at Newark was *exactly two thirds ocean water*. [I would call attention, also, to the curious fact that the amount of nitric acid in No. 12 is identical with that in the ocean water No. 13, the two being the poorest in this ingredient in the whole list, except No. 17. The animal matter in No. 12 (columns 9 and 10), doubtless comes from Newark sewage, which would accumulate in the water at flood, as at ebb.]

The chlorine test will be found of far more importance when we come to consider the waters of the upper water-shed, above the falls.

Further Observations on the Lower Passaic.—A few further remarks will be made, arising out of the examination before spoken of, on July 23d, from Newark up to Passaic. I was struck with the

* This suggestion has been taken up, as I observe (without credit), and made much of, by writers in the public press.

filthy appearance of the water in the town of Passaic, and the large amount of effete dye-stuffs there cast into the river. Proceeding down the river from this town, it was found that the stream was actually blackened, and the stain continued apparent for more than a mile. It was also observed that, even below the point at which the coloring matter had apparently precipitated, and the stream had become clear, the water had a distinct smell and taste of gas-tar, and films of tar were even occasionally seen floating thereon. This contamination must also have come from one or the other, or both of the towns above. The point where this taste was last observed was but a short way north of the viaduct of the Boonton branch of the Delaware, Lackawanna and Western Railroad. I may here add that films of gas-tar were observed by me on the water at the Jersey City Water Works in October of last year, but whether from Newark or from the up-river towns I could not say.

To be continued.

THE METALLURGY OF THE FUTURE.

An Address delivered before the Society of Civil Engineers of France on the 9th of January, 1874, by their President, M. JORDAN.

[Translated from the "Revue Industrielle."]

Since it is to you, my colleagues, that I owe the privilege of speaking here to-day, I trust you will permit me to ask your attention to the special branch of our profession to which I have devoted my energies, and, while attempting to bring before you some ideas upon what I shall call the metallurgy of the future, to show you what a fruitful field of study the iron industry can furnish, not only to those of our number who are connected actively with metallurgical operations, and have consequently at their command every opportunity for observation and experiment, but also to our Parisian brethren, who, though confined to researches more theoretical in their character, may yet be willing to consecrate to their investigation a portion of their time. I hope you will prove how easy it is to enrich our journals with original papers of great interest, and at the same time to render a service to a most important industry.

My purpose on this occasion, however, is not to occupy the time with a statement of the part which chemical science at present plays in the progress of metallurgy; a part certain to be largely increased in importance. Nor would I, even if I could, lessen this importance

in the least. But it is of course desirable for us not to confine ourselves too entirely to a study of the purely chemical questions involved; for chemistry alone will certainly not be able to reach the solution of many problems which are even now actually occupying the attention of metallurgists. To solve these questions physical and mechanical knowledge is also necessary; and it is rather in this direction than in the other that I desire to lead your thoughts for the hour.

We all, probably, have observed the significant fact, that the more the metallurgical arts progress—and we have witnessed during the past few years some marvellous advances—the more the science of heat becomes of importance in their operations. Indeed, we might almost say that the metallurgy of the future consists in largest measure in the development of this science. So that for him who will thus develop it, who will produce and control high temperatures, there seems to be in abundance both honor and profit. Even now we see about us many efforts in this direction. A never-ceasing duel is being fought between fire, whose most violent energies are roused for the combat, on the one side, and the refractory material which is to contain and to control it, upon the other. This duel recalls forcibly another contest also waged in the metallurgical arena—because in fact it is the industrial art which is really involved, not the military art—the strife between artillery and plating, between large guns and iron-clads. To construct large guns, to make them support the colossal interior pressures which correspond to the great initial velocities obtained, and which give to heavy projectiles the enormous *vis viva* which shall crush in the sides of the heaviest iron-clad before their terrible impact, taxes the profoundest resources of the metallurgist and the mechanical engineer. To manufacture plates, on the other hand, thirty, forty or even fifty centimetres thick, designed to sustain without yielding these frightful blows, to resist them without being either penetrated or even fissured, demands the most advanced skill in the iron master and at the rolls. In this Homeric duel, which has already taken on so many phases, the superiority at present is on the side of the attack. The projectile has finally triumphed over the armor. It now seems as if the result would be the same in the case of the other duel, between fire and refractory material.

Moreover—to return from our digression—how immensely inferior are the temperatures which we are actually able to obtain, to the fantastic figures which we so often have from the mouths or pens of en-

thusiastic inventors. Many practical men, even, are singularly in error in regard to the means in their possession for developing high temperatures. This is a subject which has not yet been sufficiently studied, in my opinion, in the light of modern science; or, if studied, the results have not been widely enough disseminated. I ask your permission, therefore, to point out the way in which, as it seems to me, we should study this question; and, as a preliminary thereto, to give a rapid resumé of the present condition of it in actual practice.

The great majority of metallurgical appliances where heat is generated and utilized, belong to two great classes—blast, or high furnaces, and air, or reverberatory furnaces. The former class, including both high and low blast furnaces, are among the oldest metallurgical appliances known; iron, lead, copper and tin were at one time produced exclusively in blast furnaces. Now, however, the reverberatory furnace has dethroned the low hearth and the low blast furnace, for the refining of cast iron, as it has for the manufacture of copper. Recently, in the invention of the Bessemer process, the blast furnace has seemed to take its revenge; but very soon after, thanks to the genius of Siemens, the reverberatory furnace regained the lost ground in siderurgic manufacture. And now, as a matter of fact, the Bessemer converter, fed with compressed air, and the Siemens-Martin reverberatory furnace, heated by gas and using the natural draft, divide between them, or rather yield to each other mutual assistance in, the modern industry of steel. These two methods may be regarded as the two types to which we may refer all the possible means of obtaining high temperatures, whether now known to us or hereafter to be discovered.

The more we examine the remarkable invention of Bessemer, the more we are struck with the manner in which it sprang fully armed, so to speak, from the head of its fortunate inventor. From the time of the reading, in 1856, at the Cheltenham meeting of the British Association, of the celebrated paper bearing the title "On the Manufacture of Steel and Iron Without Fuel," an entirely novel idea took possession of the metallurgical world; an idea, too, destined to be still more fruitful in results in the near future. The heating of the metal in the converter is effected without the aid of any foreign combustible substance, solely by the intermolecular combustion of the constituents of the cast iron; this combustion being effected under a pressure considerably superior to that of the atmosphere. In this way, the utilization of the heat thus produced within the metal itself

is direct and immediate. Most of it is actually absorbed by the metal, leaving but a small residue to be taken up by the walls of the converter.

The system of heating made use of by the Siemens brothers, in their furnaces, is entirely different. Here the heating is effected by means of combustible gases, produced by the distillation and imperfect combustion of coal. Their reverberatory furnaces possess two heaters, one at each end, each consisting of a sort of elongated rectangular burner, with two parallel openings, one for air the other for the gas. Both the entering air and gas are separately heated to a very high temperature. When they meet, under a pressure about that of the atmosphere, they combine and yield a powerful flame, which traverses first the furnace, where it heats the metal, and then passes through chambers filled with loosely laid fire-bricks, called regenerators. Here it gives up a large part of its remaining heat, which is to be utilized a few minutes later, in the next stage of the process, in heating the entering air and gas before their combustion. The metal forms a not very thick layer on the bed of the furnace, and is heated only by the superficial contact of the current of burning gas, and by reflection and radiation from the furnace walls, these latter being heated in advance of the metal, so that it becomes necessary frequently to cool them by artificial means (either a current of air or water) to enable them to stand the heat. The temperature of the metal on the Siemens hearth is lower than that in the Bessemer converter.

The temperature which may be obtained in a gas furnace on the Siemens system, or in the furnaces of other and more or less analogous systems which have appeared within the past few years, cannot exceed a certain maximum, which I have made some attempts to determine. The researches of Deville and Debray have proved that when we bring together, in the proportions to form water, the two gases oxygen and hydrogen, at the ordinary atmospheric pressure, all necessary precautions being taken that no part of the heat produced be absorbed by the surrounding materials, but that it be entirely confined within the products of combustion, the actual maximum temperature which is obtainable is only 2500° C., in place of 6903° , which Peclet had deduced from calculation. This discrepancy in the theoretical and experimental results is easily explained, if we remember that only one-half of the hydrogen enters into combination at 2500° under the ordinary atmospheric pressure, the vapor of the water produced having at this temperature a tendency to decompose precisely

equivalent to the affinity which, at this temperature, oxygen and hydrogen have for each other. Or, in more scientific language, at 2500° the tension of dissociation of the vapor of water is equal to the atmospheric pressure. Whatever, then, be the initial temperature of the two gases when they are mixed, we can never obtain by their combination a temperature of combustion superior to 2500° (or 2800° according to Bunsen). If the oxygen be mixed with an inert gas like nitrogen, the relative proportion of hydrogen actually entering into combination may be increased, but the actual temperature of combustion cannot be raised above this limit. But if the combustion be effected at higher pressures, at two, three, or even more atmospheres, experiment shows that the quantity of gas entering into combination goes on increasing, and that the temperature of combustion increases in the direct ratio of the pressure. Under the ordinary pressure of the atmosphere, however, the fact remains that the maximum temperature which can be produced by the combustion of pure hydrogen, a maximum impossible to attain in practice, is only about 2500° C.

The temperature of total combustion for carbonic oxide and oxygen, as determined by calculation, is 7059° , according to Peclet. But the tension of dissociation of the carbonic acid produced is considerable even at 1200° , according to Deville. Hence, although the temperature at which this tension is equal to the atmospheric pressure, that is, the temperature at which carbonic oxide and oxygen can no longer combine, has not, so far as I know, been experimentally determined; it must be certainly very far below 7000° , and probably even below 3500° .

The presence of nitrogen, when the combustion is produced by means of air, diminishes still more the temperature obtainable. Consequently, notwithstanding the great respect in which I hold the name of Faraday, I am constrained to doubt if it be possible, as Siemens tells us he said, in 1862, it would be, to obtain a temperature of 3850° C. in a furnace heated by the combustion, effected by means of air and at the ordinary pressure, of a gas containing itself more than two-thirds of inert material.

Moreover, it is necessary also to remark that in the Siemens furnace the metallic bath absorbs only a small proportion—15 to 20 per cent.—of the heat produced by the combustion; the rest being expended upon the furnace itself, in heating its walls and its regenerators, and in loss by the stack. Obviously, a flame, the weight and calorific

capacity of which are so feeble, and which is in contact with a surface of brick so much more extended than that of the molten metal, cannot furnish rapidly enough a sufficient number of heat units to raise the temperature of the furnace and the metallic bath up to that which it itself possesses, especially when the loss by conduction is taken into the account.

According to a Belgian engineer, M. Kranz, who has analyzed the working of the Siemens furnace with great care, the mean temperature of the flame on its entrance into the furnace is 3023° , that of the interior of the furnace itself being 1800° . But he does not take into the account the dissociation of the carbonic acid produced, which at this temperature must be very considerable.

It is no doubt very difficult to measure in degrees the highest temperature which can be obtained in the Siemens furnaces which are employed for melting low steel, though their inventor has undertaken to do this by means of his electric pyrometer. I believe, however, that I risk nothing in asserting that the figures of Kranz above given may be considered as a maximum.

In the Bessemer converter, owing to the small size of the opening by which the gases escape, the interior pressure is always very considerable, sometimes exceeding even by one-half the atmospheric pressure. Moreover, the carbon of the iron is burned only to carbonic oxide, which dissociates much less easily at high temperatures than carbonic acid. The silica, too, resulting from the combustion of the silicon, does not decompose at all, but remains in the liquid state in contact with the metal. For all these reasons the temperature obtained in the converter is superior to that obtained in the Siemens furnace; this temperature may be safely estimated as 3500° .

Mr. Bessemer himself understands fully the importance of effecting the combustion under a high pressure. In realization of this idea, he has quite lately, in 1869, invented a special apparatus for the purpose, a sort of hermetically closed converter, into which he blows air under a pressure of two to two and one-half atmospheres, and out of which the gaseous products of combustion issue through a very small opening, the size of which can be adjusted at pleasure. In this way he has succeeded in melting the softest iron easily, and with only a small quantity of fuel. But the direct contact of the carbon has prevented him from obtaining the melted metal sufficiently soft, a slight amount of carburization always taking place. For this reason Bessemer has abandoned this first apparatus for another, in which

the combustible does not come in contact with the melted metal. It is a sort of hermetically sealed reverberatory furnace. I am not aware in what condition these experiments are at present, nor do I know of what materials these high-pressure furnaces are constructed. But I see in all this a new proof of the originality of mind of this distinguished inventor.

What has thus far been said will be sufficient, I trust, to justify now the enunciation of the following propositions, which embody, as I conceive, the conditions necessary for the production of temperatures still more elevated than those which are at present actually in use. These propositions are :

1st. The combustible which is selected to be used as fuel must be capable of being burned within the molten metal without injury to the properties of this metal, and must yield on combustion a non-volatile product.

2d. An arrangement of furnace must be devised, heated by gas or otherwise, in which practical operations can be carried on under a pressure of several atmospheres.

It is impossible for us at present to foresee the changes which would be effected in metallurgical processes and results by the employment of temperatures more elevated than those we now actually make use of. A distinguished English physicist, J. Norman Lockyer, in a communication read to the Institute, the other day, by M. Dumas, states that during his spectroscopic investigations he has recognized the important fact, that in those stars which are hottest, only pure hydrogen is to be detected; that in those which are less hot, the metals make their appearance; in still others, yet lower in temperature, the metalloids appear; while, finally, here upon our earth, which is only an extinct star, hydrogen no longer exists free, and but a few metals and metalloids are found in this condition; while we do find an immense number of compounds of all degrees and kinds of complexity. It is easy to see from this statement of Mr. Lockyer that he considers hydrogen gas to be the ultimate limit of all dissociation; to be what Balzac, in a recent and well-known novel, calls the "absolute," and what others have called "cosmic matter." Hence he must believe that all bodies are simply metamorphoses or transformations of hydrogen, due to variable circumstances of pressure, temperature and electric state. It is hardly probable, however, that we shall ever see the number of our elements reduced to one. But shall we ever be able to carry dissociation to a degree sufficient to separate even recognized

elements from each other? to dissociate, for example, iron and oxygen, or iron and phosphorus? It must be confessed that nothing that we know as yet permits us to hope for it. But, precisely as the Bessemer and Siemens-Martin methods have given us cast steel in enormous masses, so methods may be devised, still more energetic, which shall enable us to obtain this and other metals in molecular states which are now unknown. Let me detain you a few moments upon this point.

To be continued.

ON THE STRENGTH, ELASTICITY, DUCTILITY AND RESILIENCE OF MATERIALS OF MACHINE CONSTRUCTION,

And on Various Hitherto Unobserved Phenomena, Noticed during Experimental Researches with a New Testing Machine, fitted with an Autographie Registry.

BY PROF. R. H. THURSTON.

(Continued from page 293.)

8.—LOW STEELS.—In Plate II, and above the curves just described, are a set obtained during experiments on “low steels,” produced by the Bessemer and Siemens-Martin processes. In general character, the curves are seen to resemble those of the standard irons, as illustrated by Nos. 1 and 6. The irons contain usually barely a trace of carbon. These steels contain from one-half to five-eighths of one per cent. The irons are made by a process which leaves them more or less injured by the presence of impurities, from which the utmost care can seldom free them. The steels are made from metal which has been molten and cast, a process which allows a far more complete separation of slag and oxides. The low steels, however, are liable to an objectionable amount of porosity, due to the liberation of gas while the molten mass is solidifying, whenever the spiegeleisen, employed as a conveyor of carbon, is not very rich in manganese. The results of these differences in constitution and treatment are readily seen by inspecting the curves. They show a stiffness equal to No. 6, and about the same degree of internal strain. They contain a sufficient number of the capillary channels, produced by drawing down the pores while working the ingot into bar, to cause a lack of homogeneity in structure, very similar to that produced in iron by cinder. They have a much higher elastic limit, and greater strength, and the softer grades have great ductility. In resilience, these softest steels excel all other metals, except the unusual example, No. 22, and are

evidently the best materials that are now obtainable for all uses where a tough, strong, ductile metal is needed to sustain safely heavy shocks. A comparison of the diagrams of two competing metals may thus be made to indicate how far a difference in price should act as a bar to the use of the costlier one. For many purposes, a metal having double the resilience of another is worth more than double-price. For general purposes, a comparison of the resilience of the metals within the elastic limit is of supreme importance. No. 6 is seen to have more resilience within this limit than No. 1, and the steels far more than either; but No. 1 would take a set of considerable amount far within the true elastic limit, as indicated at *a*. The most valuable measure is obtained by determining the area intercepted between the "elastic line" and the perpendicular let fall from its upper end; this measures the resilience of elastic resistance, which is the really important quality.

No. 98 was cut from the head of an English Bessemer rail made from unmixed Cumberland ores. It contains nearly 0.4 per cent. carbon. It is quite homogeneous, has a limit of elasticity at 88 foot-pounds of torsional, or 26,400 pounds per square inch tensile stress, approaches its maximum of resistance rapidly, and, at 210°, the torsional moment becomes 225 foot-pounds, equivalent to 67,500 pounds per square inch tensile stress. It only breaks after a torsion of 283°, and with an ultimate elongation of 80 per cent., equivalent to a reduction of cross section to 0.556.

No. 76 is a Siemens-Martin steel made from mixed Lake Superior and Iron Mountain ores, and contained about the same amount of carbon as the preceding. It contains rather more phosphorus, which probably gives it its somewhat greater hardness, its higher limit of elasticity and its somewhat reduced ductility. Its elastic limit is found at 104 foot-pounds of torsion, or 31,200 pounds tensile resistance, and its ultimate strength is almost precisely that of the preceding specimen. Its elongation is 0.66 maximum. Unless more seriously affected by extreme cold than No. 98, it would be preferred for rails, and, perhaps, for most purposes.

No. 67 is a somewhat "higher" steel, made by the same process. It is less homogeneous than the two just examined, has greater strength and a higher elastic limit, but less ductility. Its resilience is very nearly the same as that of Nos. 98 and 76. The elasticity of all of these steels seems very exactly the same. The ductility of No. 67 is measured by 0.40 elongation. At *d*, is seen another illustration

of elevation of the elastic limit. The piece was left twenty-four hours under maximum stress. The torsional force was then removed entirely. On renewing it, as is seen, the resistance of the specimen was found increased in a marked degree.

No. 69 is an American Bessemer steel, containing not far from 0·5 per cent. carbon. The same effect is seen here that was before noted, an increase of hardness, a higher elastic limit, and greater strength, obtained, however, by some sacrifice of both ductility and resilience. The elastic limit is approached at 130 foot-pounds of torsional moment, or 39,000 pounds tensile, and the maximum is 280 foot-pounds of moment and 84,000 pounds tensile resistance at 133° . Its maximum angle of torsion is 150° , its elongation 0·24.

No. 85 is a singular illustration of the effects of what is probably a peculiar modification of internal strain. It seems to have no characteristics in common with any other metal examined. Its diagram would seem to show a perfect homogeneousness as to strain, and a remarkable deficiency of homogeneity in structure. It begins to exhibit the indications of an elastic limit at α , under a torsional moment of 110 foot-pounds, or an apparent tensile stress of 33,000 pounds per square inch, and then rises at once by a beautifully regular curve, to very nearly its maximum at 16° , and 176 foot-pounds. The maximum is finally reached at 130° , and thence the line slowly falls until fracture takes place at 195° . The maximum resistance seems* to be very exactly 60,000 pounds to the square inch. Its maximum elongation for exterior fibres is about 0·23. The resilience taken at the elastic limit is far higher than with common iron, and it is seen that this metal, in many respects, may compete with steel. Its elasticity is seen to remain constant wherever taken. This singular specimen was a piece of "cold rolled" iron. It is probably really far from homogeneous as to strain, but its artificially produced strains are symmetrically distributed about its axis, and being rendered perfectly uniform throughout each of the concentric cylinders into which it may be conceived to be divided, the effect, so far as this test, or so far as its application as shafting, for example, is concerned, is that of perfect homogeneousness. The apparently great deficiency of homogeneousness in structure is readily explained by an examination of the pieces after fracture; they are fibrous, and have a grain as thread-

* With an exceptional case, of which this is an example, the scale for tension is incorrect. The tensile strength is probably higher than here given.

like as oak ; their condition is precisely what is shown by the diagram, and the metal itself is as anomalous as its curve.

8.—TOOL STEELS.—The “tool steels” differ chemically from the “low steels” in containing a higher percentage of carbon, and usually, in being very nearly, if not absolutely, free from all injurious elements. They are made in crucibles by melting down the blister steels which are the crude product of the process of cementation, or sometimes, by melting a charge composed of selected iron, a small proportion of manganese bearing alloy and the proper amount of carbon. Containing a higher proportion of carbon than the preceding class of metals, it is comparatively easy to secure homogeneousness by the introduction of manganese, and by the same means, to eliminate very perfectly the evil effects of any small proportion of sulphur that may be present. Their comparatively large admixture of carbon makes them harder, and reduces their ductility, and since the reduction of ductility occurs to a greater degree than the increase of strength, the effect is also to reduce their resilience. The working of these metals is more thorough than is that of the less valuable steels, or of iron. They are cast in comparatively small ingots, and are frequently drawn down under the hammer, instead of in the rolls, and are thus more completely freed from that form of irregularity in structure noticed so invariably in steels otherwise treated. The effect of increasing the proportion of carbon, is to confer upon iron the property of hardening, when heated to a high temperature, and suddenly cooling, and the invaluable property of “taking a temper,” *i. e.*, of assuming, under proper treatment, any desired degree of hardness. The hard steels are, however, comparatively brittle, the hardening being secured at the expense of ductility. The effect produced upon the tenacity of unhardened steel, by increasing proportions of carbon, is somewhat variable, since it is influenced greatly by the presence of other elements. For good steels unhardened, the writer has been accustomed to estimate tenacity by the following formula, which is approximately accurate, and may be often found useful :

$$T = 60,000 + 70,000 C.$$

in which T represents the tenacity in pounds per square inch, and C is the percentage of carbon contained in the metal. This subject will be considered at greater length after a series of experiments have been made to obtain more exact determinations.

Referring to Plate II, a set of diagrams will be found, having their origin at 180° , which are *fac similes* of those automatically produced during experiments upon various kinds of tool steels.

No. 58 is an English metal, known in the market as "German crucible steel." It is remarkable as having a condition of internal strain which has distorted its diagram to such an extent as to completely hide the usual indication of the elastic limit. A careful inspection shows what may be taken for this point at about $14\frac{1}{2}^{\circ}$ of torsion, when the twisting moment was about 120 foot-pounds, and the tensile resistance 36,000 pounds per square inch. The metal is homogeneous in structure, has an ultimate resistance of 302 foot-pounds of moment, or 90,600 pounds per square inch tensile resistance. Its resilience is evidently inferior to that of the softer metals, and also less than the next higher and better grades. This metal contains about 0.60 to 0.65 per cent. carbon. Its elongation amounts to 0.045.

No. 53 is an English "double shear steel," of evidently very excellent structure, but less strong and less resilient than the preceding. Its exterior fibres are drawn out three per cent.

Nos. 41 and 61 are two specimens of one of the best English tool steels in our market. The first was tested as cut from the bar, but the second was carefully annealed before the experiment. In this instance, annealing has caused a slight loss of resilience as well as a decided loss of strength. In No. 41, the limit of elasticity can hardly be detected, but seems to be at about the same point as in No. 61, at near 130 foot-pounds moment and 39,000 pounds tension. The ultimate strength is nearly 119,000 pounds per square inch. The proportion of carbon is very closely 1 per cent. Its section would reduce by tension, 0.05.

No. 70 is an American "spring steel," rather hard, but as shown by its considerable resilience, of excellent quality, resembling remarkably the tool steel No. 41. It differs from the latter, apparently by its much higher elastic limit. It is possible that this may have been caused by more rapidly cooling after leaving the rolls in which it was last worked. It is evident that, for exact comparison, all specimens should be either equally well annealed or should be tempered in a precisely similar manner, and to the same degree.

Nos. 71 and 82 are American tool steels, containing about 1.15 of carbon. The former is notable as having an elastic limit at 69,000 pounds, and a probable deficiency of manganese, producing the usual indication of heterogeneous structure. Both of these steels lack resilience, and are less well adapted for tools like cold chisels, rock drills, and others which are subjected to blows, than for machine tools.

They have a maximum elongation, respectively, of but 0.013 and 0.03.

Interesting and instructive as the study of these curves may be made, the information obtained from them is supplemented, in a most valuable manner, by that obtained by the inspection of the fractured specimens, upon which the peculiar action of a torsional strain has produced an effect in revealing the structure and quality of the metal that could be obtained in no other way.

Fig. 8 represents the appearance of No. 68, and Fig. 9 that of No.

Fig. 8.

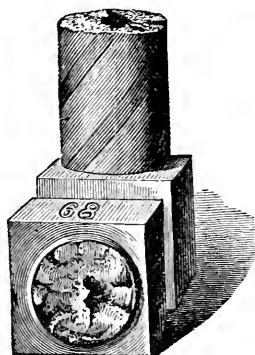
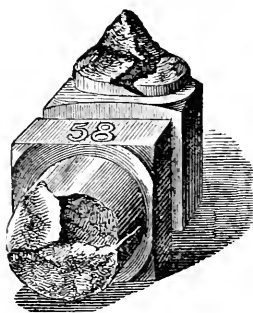
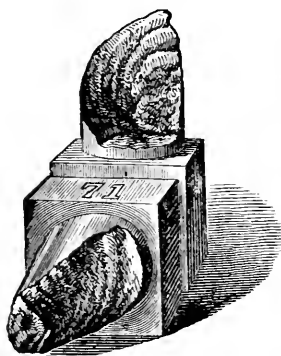


Fig. 9.



58, while the peculiarities of the finest tool steels are seen in No. 71,

Fig. 10.



as shown in Fig. 10. The smooth exterior of No. 68, which is a companion specimen to that giving diagram 69, and its bright and characteristic fracture, resembling that of No. 22 somewhat, together indicate its nature perfectly, the first feature proving its strength and uniformity of structure, and the second showing, even to the inexperienced eye, its toughness. This is a representative specimen of low steels. No. 58 is seen to have retained, even more than No. 68, its original smoothly polished surface. Its fracture is less waxy, and much

more irregular and sharply angular. The crack running down the side of the neck shows its relationship to the shear steels which much oftener exhibit this effect of strain, in consequence of their lamellar character. No. 58 is evidently intermediate in its character between

the soft steels, like No. 68, and the tools steels which are represented by No. 71, Fig 10. In this test-piece, the fracture is ragged and splintery, and the separated surfaces have a beautifully fine, even grain, which proves the excellence of the material. The surface which was turned and polished in bringing the metal to size remains as perfect as before the specimen was broken. By an inspection of the broken test-pieces in this manner, the grade of the steel, and such properties also as are not revealed by an examination of the diagram of strain, are very exactly ascertained by a novice, and to the practical eye, the slightest possible variations are readily distinguishable.

9. CAST-IRON.—The diagrams of strain having their commencement at 100° , have been obtained from cast-iron and from malleableized cast-iron.

Nos. 23 and 24 are those given by a good dark grey foundry iron from Pennsylvania. No. 25 represents the curve of light grey scrap, and 30 is from a very fine white Lake Superior charcoal iron. The latter is seen to be exceedingly hard and rigid, the resistance of the piece rising very precisely in proportion to the angle of torsion until it snaps at last under a moment of over 200 foot-pounds, equivalent to a tension of 60,000 pounds per square inch, and with a maximum elongation of one tenth of one per cent. This is a most extraordinary resistance, but it is evident that, notwithstanding its immense strength, this material would be valueless for ordinary purposes in consequence of its excessive brittleness. When the torsional effort had reached about one-half its maximum amount the piece was released. The pencil retreated along a nearly vertical line *e*, which it again traversed as the strain was gradually renewed. Here as in many other cases, where a similar experiment was made, evidence is given of the truth of the statement originally made by Hodgkinson,* that every load produces a set. As will be shown, subsequently, however, it is not true in perfectly homogeneous bodies free from strain, and within their elastic limit. The light grey iron has a limit of elasticity at near one-half the maximum reached by the white iron, without any sign of reaching the limit of its elasticity. The grey has more ductility than the white iron, but has only about two-thirds the resilience of the latter. The dark grey irons are evidently better than either of the lighter grades, except in power of carrying an absolutely static load. The actual stretch of the outer surface particles

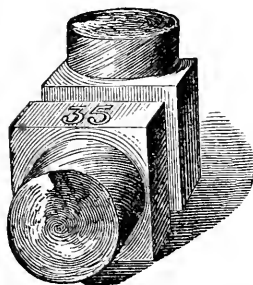
* Reports of British Association; also Civil Engineer and Architects Journal.

is very nearly the same in all three. They are excellent specimens of their class, and considerably better than ordinary irons.

No. 37 is a "malleableized cast-iron," made from the extraordinary metal illustrated in No. 30. The process of malleableizing consists in decarbonization by heating the casting made from good white iron, in contact with iron oxide or other decarbonizing material. Without removing any other constituent than the carbon, it produces a crude steel or an impure wrought-iron. When performed in the usual manner, melting the cast-iron in a cupola in contact with the fuel, and with some flux, and then carrying the process of malleableizing to the usual extent, a metal is obtained such as is illustrated by the diagram marked 37. It retains the strength of the cast-iron, and acquires some ductility.

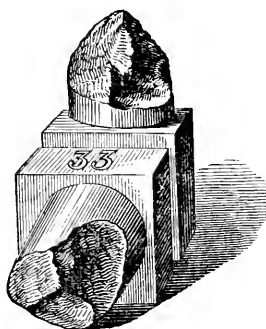
No. 30 yielded 7° before fracture, while No. 37, vastly more

Fig. 11.



ductile and resilient, only broke after a torsion of 39° , and a maximum elongation of 2 per cent. Taking the precaution to melt the iron in an "air furnace"—a form of "reverberatory"—and conducting the process of malleableizing more carefully, a

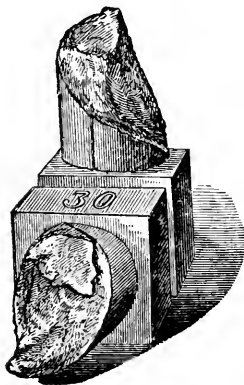
Fig. 12.



still more valuable material was obtained.

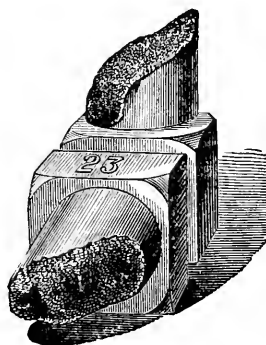
No. 35 represents this iron. Its resemblance to wrought-iron, both in appearance of fracture and in its strength and ductility, are

Fig. 13.



greatly increased. It has a high limit of elasticity—over 20,000 lbs. per square inch—and such ductility that it only breaks after a torsion of nearly 168° , and an elongation of "fibre" of 0.35. It is not very homogeneous, but it is as strong, and almost as tough, as a good wrought-iron. This material has

Fig 14.



especial value for many purposes, because of the facility with which awkwardly shaped pieces can be made of it. In many cases, it will prove as good as wrought-iron and far cheaper.

Fig. 11 shows the appearance of this last specimen. Its resemblance to wrought-iron is very noticeable. The lines running like the thread of a screw around the exterior of the neck, and the smooth even fracture in a plane precisely perpendicular to the axis, are the instructive features. Fig 12, representing No. 33, is a specimen similar in character to No. 37. The comparative lack of ductility, its less regular structure, and its less perfect transformation are perfectly exhibited. Fig 13 is an excellent cut of the white iron as cast and without malleableizing. Its surface, where fractured, has the general appearance of broken tool steel. The color and texture of the metal are distinctive, however. It has none of the "steely grain." Fig. 14 represents the dark grey iron. Its color, its granular structure and coarse grain are markedly characteristic, and no one can fail to perceive, in the specimen, the general character which is exactly given by the autographic diagrams of the testing machine.

10. OTHER METALS.—The diagrams numbered 87, 88 and 89, are those of copper, tin and zinc. These specimens are all of cast metal, carefully selected under the direction of the writer, and molded and cast at the Stevens Institute of Technology. They exhibit neatly the wonderful superiority which the various kinds of iron and steel possess over the other useful metals. These metals all take a set under very small strains, pass their limits of elasticity at some indeterminable, but evidently low point, and possess very slight tenacity.

Zinc, No. 89, by the regularity of its curve shows a very uniform structure. It increases very gradually in resistance to torsion, until it reaches the angle 50° , at which point it has a moment of torsional resistance of 36 foot-pounds, and a maximum tenacity of about 10,800 pounds per square inch. It loses its power of resistance, after rupture commences, as regularly, but not as slowly, as it acquired it, and rupture becomes complete at 63° . Its resistance is exceedingly small, and it is evidently unfit to bear either static or dynamic force. Its stretching power has a maximum of 0.04.

Tin, No. 88, is equally remarkable for its exceedingly feeble resistance and its great ductility. The specimen was excellent, both in quality of metal and in closeness of structure, as was indicated by the clearness of the "tin cry" heard while undergoing the test and by the fine, smooth, clean fracture. The character of the curve is simi-

lar to that of zinc, but has far greater extent. Its elastic limit is quite indeterminable. The outline of the diagram indicates very perfect homogeneousness. The maximum resistance to torsion is found at 240° , and under a stress of 19 foot-pounds. Its tenacity deduced from the diagram is, at most, but 5,700 pounds per square inch. Rupture occurs very gradually, and the piece separated entirely at 355° . Notwithstanding its great ductility, its low tenacity produces a low resilience, although in this quality it excels zinc, which latter metal had nearly double its strength. Its elongation by tension would have reduced its section to 0.6 of the original cross area, if that reduction were proportional to the ductility shown by the diagram.

Copper, No. 87, cast in green sand, like the zinc and tin just described, was found, on examination of the fracture, to differ from them in being exceedingly porous. The effect of this fault has been to weaken it seriously. Its curve closely resembles that of zinc, but is abruptly terminated by the piece suddenly breaking off at 46° . It reaches a maximum sooner than zinc, at 29° , and its greatest resistance to torsion is 36 foot-pounds, or to tension 10,800 pounds per square inch, precisely the same as zinc. Its ductility has a value of one and a half per cent. Its resilience is somewhat less than that of zinc. Its limit of elasticity is difficult to determine, but has been taken at $1\frac{1}{2}^{\circ}$ where the moment of resistance is 13 foot-pounds, equivalent very nearly to 3,900 pounds tenacity, per square inch.

No. 134 is the curve of cast copper, precisely similar to No. 87, but cast in a dry sand mold. The marked difference between these specimens is probably due, not only to the difference in degree of porosity which arises from the presence of vapor, which permeates the casting in one case, filling it with bubble holes, and which is almost unobservable in the last, but the slower cooling of the dry sand casting also probably produces its effect in strengthening the metal. This last specimen has a limit of elasticity at not far from $13\frac{3}{4}^{\circ}$, and under a torsional stress equivalent to a tension of 5,400 pounds per square inch. The maximum values of these quantities are found at 21° , and are 42 foot pounds, and 12,600 pounds per square inch respectively. The resilience of the specimen is much greater than that of the preceding, and its maximum elongation is .026. Altogether, this is far better than the preceding, and it would seem that copper, and probably all its alloys, should, when possible, be cast in dry sand, to secure density and strength.

No. 141 is a piece of forged copper, hammered into a one-inch

square bar, from a piece originally $3\frac{1}{2}$ inches wide and $\frac{3}{4}$ inch thick. The most striking property noticed is its immense ductility, far exceeding that of any other piece of metal yet tested, and, in amount, many times as great as the cast metal. Its limit of elasticity is reached very quickly, although it is impossible to say precisely where it occurs. Comparing its "elastic line" with the initial portion of the curve, it is seen that the slightest force produces a set which is proportionally large as compared with the sets of other metals. The curve rises very regularly and gradually to a maximum, which is only attained, however, after a total angle of torsion of 450° , and which measures 96 foot-pounds moment, or 28,800 pounds per square inch. Rupture is finally obtained after a torsion of 543° . The maximum elongation is 210 per cent., the most elongated lines of particles being finally left of 3.1 times their original length. Had this change of form occurred by reduction of section, the fractured area would have been but .323 the area of original section. The resilience of this piece of metal is evidently insignificant within the limit of which it would be seriously distorted by a blow, but is quite large in amount where resistance extends to the point of rupture. This is perfectly consonant with that knowledge of the material which every mechanic derives from experience with it. Here, however, we have a complete account of its properties, written out by the material itself with definite and accurate measures.

11. GENERAL CONCLUSIONS.—These plates, exhibiting the diagrams, which are the autographs of all the useful metals, illustrate sufficiently well the remarkable fullness and accuracy with which their properties may be graphically represented, and the convenience with which they may be studied, with the aid of so simple a recording machine. A comparison of results deduced as shown, with those obtained, so far as they can be obtained at all, the usual method of simply pulling the specimens asunder, and trusting to, sometimes, unskillful hands and an untrained observer, for the adjustment of weights and the registry of results, will indicate the close approximation of this method in even ascertaining the behavior of the metal in tension. On examining the beautifully plotted curves given by Knut Styffe, as representing the results of the experiments, made by him and by his colleagues, with a tensile machine, no one can fail to be struck with the similarity of those diagrams to the curves here produced automatically, and it will be readily believed that not only must there be very perfect correspondence of results where the two methods are carefully compared, but, also, that any theory of rupture must be defective

which does not apply to both cases. The equations of the curves here given and those of the curves obtained by Styffe must have forms as similar as the curves themselves.

The constant ratio here assumed between the torsional resistance and the tensile strength of the metals, and of homogeneous materials generally, is based upon a comparison of the results here given with those obtained from the irons by tensile test, by the writer, and is confirmed by a compilation of results given by other experiments on the same brands.

12. TESTING WITHIN THE LIMIT OF ELASTICITY.—In determining the value of materials of construction, it is usually more necessary to determine the position of the limit of elasticity and the behavior of the metal within that limit than to ascertain ultimate strength or, except, perhaps, for machinery, even the resilience. It is becoming well recognized by engineers who are known to stand highest in the profession, that it should be possible to test every piece of material which goes into an important structure and *to then use it* with confidence that it has been absolutely proven to be capable of carrying its load with a sufficient and known margin of safety. It has quite recently become a common practice to test rods to a limit of strain determined by specification, and to compel their rejection when found to take a considerable permanent set under that strain. The method here described allows of this practice with perfect safety. The limit of elasticity occurs within the first two or three degrees, and, as seen, the specimen may be twisted a hundred, or even sometimes two hundred times as far without even reaching its maximum of resistance, and often far more than this before actual fracture commences. It is perfectly safe, therefore, to test, for example, a bridge rod up to the elastic limit, and then to place the rod in the structure, with a certainty that its capacity for bearing strain without injury has been determined and that formerly existing internal strain has been relieved. The autographic record of the test would be filed away, and could, at any time, be produced in court and submitted as evidence—like the “indicator card” of a steam engine—should any question arise as to the liability of the builder for any subsequent accident, or as to the good faith displayed in fulfilling the terms of his contract. A special machine has been designed for this case.

13. The above will be sufficient to show the use and the value of this method. In the course of experiment upon a large number of specimens of all kinds of useful metals and of alloys, a number of interesting and instructive researches have been pursued, and some

unexpected discoveries have been made. Before taking up the theory of rupture, the construction of equations, and the determination of their constants, a section will be devoted to an account of these investigations.

BARYTA—ITS MANIFOLD USES IN THE ARTS.*

By DR. LEWIS FEUCHTWANGER.

The various salts of baryta have long been employed in pyrotechny; as admixture to white lead; as material almost indispensable to card makers for a permanent white; in sugar refining; in chemical operations, etc.

In nature we find but few varieties. The sulphate, composed of 66 per cent. baryta and 34 per cent. sulphuric acid, is abundant in England, France, Germany and the United States, where it most generally is found in connection with beds or veins of metallic ores, as gangue, or veinstone. Sometimes, however, it forms distinct veins, in company with secondary limestone, and very often in fine crystals, along with calcite and celestite. Crystals of large dimensions occur in Westmoreland, Cornwall, Cumberland and Derbyshire, in England. Beautiful specimens of septaria, cut and polished for table and other ornaments, having linings of brown heavy spar, are wrought in Durham, England, in Hungary, at Freiburg in Saxony, Clausthal in the Hartz, in Bohemia, and in Auvergne, France.

The localities in the United States are very numerous. The States of Connecticut and Missouri have long furnished abundant material for the arts. Next come Virginia, New York, New Hampshire, Massachusetts, Pennsylvania, Kentucky, and Tennessee. In Canada fine crystals occur, and massive baryta in a 27-foot vein. It is reported from New Mexico also.

The Bologna spar is the ornamental stone, of a brown color and concentric rings, originally found in a bed of clay near Bologna, where it formerly was considered a great curiosity, on account of its phosphorescence, displayed after heating with charcoal, and it was called the Bologna phosphorus. The common name of sulphate of baryta is heavy spar or barytes; specific gravity 4.5, and hardness 3. It is found in nature in large crystals, weighing 100 lbs. and more, and in slender needle crystals; also in massive aggregations of tab-

* A paper read before the Polytechnic Club of the American Institute, Dec. 4th, 1873. (Communicated by the author.)

ular crystals likewise columnar and radiated, and in globular and nodular concretions ; also lamellar and granular, earthy and stalactitic.

The sulphate of baryta often occurs associated with lime and some silica and alum, and is then called calcareobarite ; and if it is associated with strontia, it is called baryto-celestine. If the sulphate of baryta gives out a fetid odor on striking or rubbing it, it is called fetid baryta. The name of baryta is derived from the Greek language, βαρυς, heavy.

Witherite is a carbonate of baryta, having a specific gravity of 4·, and a hardness of 3·2, and consists of 78 per cent. of baryta and 22 per cent. of carbonic acid. This mineral is found in considerable quantities in England, at Alston Moor in Northumberland, in Silesia, Hungary, Styria, Sicily, Chili, but not much in the United States. It is extensively employed in the manufacture of plate glass and the manufacture of beet root sugar in France, and for the production of *blanc-fixe*, or permanent white ; it is much used of late for paint, particularly in combination with soluble glass and white oxide of zinc.

The metallic base of the baryta salts is called barium, and is obtained from the carbonate of baryta or chloride of barium, if put in a platinum dish and connected with the positive pole of a strong galvanic battery, in order to decompose it, mercury being placed in a hollow made in the baryta and connected with the negative pole. The result is an amalgam, which may be distilled in a bent tube filled with hydrogen. Barium is a white, malleable and fusible metal, which oxidizes easily in the air and decomposes water at common temperatures. For the purpose of obtaining the pure baryta or barium oxide, the nitrate is calcined at a red heat in a silver or porcelain crucible, or the carbonate is mixed with pulverized charcoal in a covered crucible, and exposed for an hour to a strong heat. If oxygen gas is passed over it, it will absorb that gas with avidity and become a peroxide. This is the substance used at the present day for production of the peroxide of hydrogen, which is much recommended as a medical reagent, and employed in the arts for bleaching animal tissue, or converting brown into blonde hair. To prepare it, the peroxide of barium is treated with hydrochloric acid, and the liquid, previously decomposed with sulphate of silver, is carefully evaporated to a syrupy consistency, when it yields a slight chlorous odor. It decomposes easily into water and oxygen, and it is therefore almost impossible to prepare it properly in hot weather. At 212 deg. F. it decomposes with violence.

The oxide of barium, or caustic baryta, unquestionably rivals in its causticity, potash, soda and ammonia, and may be easily employed in the compounds with chromic acid.

The chloride of barium is obtained by fusing the sulphate of baryta, or native heavy spar, with chloride of calcium (the residue from the preparation of ammonia), in a reverberatory furnace, and subsequently extracting with hot water, leaving the sulphate of lime undissolved.

The chlorate of baryta, which is now extensively used for producing a green flame in the manufacture of fireworks, is prepared by dissolving artificial carbonate of baryta in chloric acid solution, when it forms beautiful shining tabular crystals. It is dangerous to keep on hand when mixed with charcoal or sulphur.

Nitrate of baryta, which is likewise used in fireworks, may be easily prepared by dissolving the native carbonate in nitric acid and evaporating the solution, whereby octahedral crystals of the nitrate are deposited.

The native sulphate of baryta is generally used for the adulteration of white lead or paint, to the extent of 25 to 50 per cent. Of this mineral 4,000 tons are produced annually in Connecticut, and 2,000 tons in Missouri, while 10,000 tons are imported from England and Germany. The native mineral, if very white and free from iron coating is finely ground and floated with water. But most of the native mineral contains fine particles of iron, and hence requires a different treatment, namely, calcination for some hours, in order to oxidize the iron to a higher degree, when hot water and, if necessary, a little sulphuric acid, will take up all the iron, and a beautiful white heavy powder is deposited, which is then dried, either by steam or in the same manner as whiting is dried, in the atmosphere. White oxide of zinc, as well as white lead, may be mixed with sulphate of baryta in linseed oil to a pigment, which is then fit for in- and outdoor painting, and spreads well.

The artificial sulphate, called white or *blanc fixe*, which is now largely manufactured in France, England, and the United States, is used in the manufacture of a paper of the purest white, in imitation of linen, and used for cheap collars, skirts and cards. It was formerly manufactured from the native carbonate of baryta, but is now prepared from chloride of barium, which is obtained in England as a waste product at a reduced price. This is decomposed with sulphate of ammonia, and pure sulphate of baryta is precipitated. Another process for obtaining the chloride of barium, in order to prepare the permanent white, is by the decomposition of the native

sulphate of baryta with chloride of sodium in a strong fire, and the subsequent solution of the fused mass in boiling water. The result is chloride of barium and sulphate of soda or glauber salt. About 5,000 tons of permanent white are annually manufactured in this country and Europe.

In the chemical laboratory, the barium salts are indispensable for the determination of sulphuric acid, which forms the sulphate as an insoluble precipitate. The carbonate of baryta is a strong poison to animals, and is used for killing rats, etc.

A green paint, composed of manganese and caustic baryta, under the name of manganese green, has been brought to market from abroad, but was soon superseded by the beautiful Guignet green, a composition of aniline and iodine.

The beet sugar refiners of France have very successfully employed both caustic baryta and the carbonate in their operations. They treat, first, the saccharine juice with lime and then with carbonic acid, in order to clarify it. Afterwards they add baryta in order to obtain an insoluble precipitate, a saccharate of baryta. After passing sufficient carbonic acid gas under a pressure of about half an atmosphere upon this precipitate, a separation takes place and, without any evaporation, the hot solution is left to crystallize.

In copper metallurgical operations, the sulphide of barium has latterly been employed for the purpose of precipitating from an ammoniacal copper solution the copper as a sulphide, which is treated in the usual method for reduction, either by caustic lime, or by borax, or by a galvanic current.

The artificial carbonate of baryta, obtained by passing carbonic acid gas through a sulphide of barium, whereby the carbonate of baryta is precipitated, is much used in Europe in glass making for producing an achromatic glass. In 1826, I assisted in Jena my teacher, Koebner, in experiments for this object.

The Canal across the Corinthian Isthmus.—The Greek Government has granted permission to cut a canal across the isthmus at Corinth, under the following conditions :

The canal is to be 42 meters (137 ft.) wide at top, and $3\frac{1}{2}$ meters ($11\frac{1}{2}$ ft.) in minimum depth. In the middle of its length there is to be a dock with warehouses, covering 300,000 square meters (74 acres). The work is to be completed in six years, and the concession to the company is for ninety-nine years. The cost is estimated at 200 millions of francs.

On the Effect of Phosphorus on Steel.—At the February meeting of the French Society of Civil Engineers, M. Euverte, director of the steel works at Terrenoire, communicated some details relative to the experiments which have been in progress for the past two years at those works, in order to ascertain the point at which the presence of phosphorus in steel becomes injurious. They were led to these experiments by the difficulties they encountered in freeing the metal from this substance. The metal containing the phosphorus was treated in a Siemens-Martin furnace, in the usual way, the charge of ferro-manganese added containing 42 per cent. of manganese. Not only in the first experiment, but in all the subsequent ones, the metal obtained was malleable and of excellent quality. Hence, M. Euverte concludes that phosphorus may exist in the steel without injury, provided that the carbon be at the same time proportionately diminished. The amount of phosphorus which may be present without affecting either the tensile strength of the steel or its malleability is variable; rails of great excellence were made of steel containing 0·3 per cent. of phosphorus and 0·15 of carbon. Though not recommending the addition of phosphorus, M. Euverte believes that, for special uses, steel which contains it, provided the carbon is low, will take an important place in the arts.

A New Theory of Waterspouts.—It has been hitherto assumed that the column of air which revolves to produce a waterspout is an ascending column. M. Faye, the astronomer, has recently maintained before the French Academy the theory that the air in these columns is a descending one. Precisely as in a river, vertical layers of water, moving with different velocities, form whirlpools in shape like funnels, drawing the water away from the center, so, when currents of air above the clouds move in different directions, or in the same direction with different velocities, they produce upon their borders a gyratory motion of the interposed air. This air descends like the water in the whirlpool, and if the gyratory movement be powerful enough, the tube of rotating air may reach the earth. At the same time the centrifugal force determines the matter to the exterior, and causes a partial vacuum in the interior, thus explaining the lifting of objects over which the whirlwind passes, and in the case of water producing waterspouts. Of course the barometer in the centre experiences a sudden fall. The solar spots Faye explains in this way, supposing them to be whirlwinds seen vertically. The solar gas drawn into them being cooler, appears as the dark umbra.

Completion of an Immense Safe.—Mr. Chubb, the well-known English manufacturer of safes, has recently completed, for the Government of Buenos Ayres, an iron safe of gigantic dimensions, designed to receive the title-deeds and securities of the Department of Public Credit. It is a parallelopiped formed by plates of heavy iron, strongly riveted at the edges. Within this is a second box as solidly constructed as the first, and separated from it by an air-space. In this interior safe the valuable property is placed. The interior filling is made with a composition whose character is at present a secret, but which appears to have a certain quantity of alum in it. The dimensions of the safe are : height, eleven feet six inches ; length, fourteen feet nine inches ; depth, five feet. The plates are three-quarters of an inch in thickness, and at the corners the total thickness of the plates and braces is nearly five inches. Two doors, one and one-quarter inches thick, give access to the interior. They are made of steel and iron, and have compartments filled with non-conducting material. Two safety locks are attached, containing each a charge of gunpowder capable of firing fourteen projectiles in all directions. Each lock is of a different form. The safe, entire, weighed fifteen tons. It was shipped in pieces, and is to be put together at its destination by a competent mechanic, who accompanied it for that purpose.

Franklin Institute.

HALL OF THE INSTITUTE, April 15th, 1874.

The meeting came to order at the usual hour, with President Coleman Sellers in the chair.

The minutes of the previous meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting held April 8th, the following donations had been received, to wit :

Dictionary of Elevations, and Climatic Register of the United States, &c. By J. M. Tonner, M.D. From the Author.

United States Textile Manufacturers' Dictionary ; comprising Woollen, Cotton, Silk, Jute, Flax and Linen Establishments. 1874. From the National Wool Manufacturers' Association of America, New York.

Transactions of the American Institute of Mining Engineers, Vol. 1. May, 1871, to Feb., 1873. From the Institute.

Report on the Swinburn Breech-loading Rifle. By J. Beverley Fenby, Esq., C. E., &c. From the Author.

Proceedings of the Academy of Natural Sciences, of Philadelphia, Part 3d. October to December, 1873. From the Academy.

Memoirs of the Geological Survey of India, Vol. 1 (No. 1), Vol. 4 (Nos. 3, 4), and Vol. 10 (Pt. 1). Calcutta. From the Superintendent.

Records of the Geological Survey of India, Vol. 6 (Pts. 1—4). 1873. Calcutta. From the Superintendent.

Annales des Ponts et Chaussées for September and October, 1873. Paris. From the Editor.

The Actuary likewise reported the following communication from the Committee on Science and the Arts, and the action of the Board thereon:

To the Board of Managers of the Franklin Institute:

GENTLEMEN,—At the stated meeting of the Committee of Science and the Arts, held March 6th, 1874, a resolution was passed, instructing me to recommend to you the award of the Scott Legacy Premium and Medal to George Westinghouse, Jr., of Pittsburgh, Pa., for his improvements in air brakes for railway trains.

Respectfully,

JOHN C. CRESSON, *Chairman Com. S. and A.*

Philadelphia, March 26, 1874.

The following is the action of the Board on the above: On motion, it was

Resolved, That, in accordance with the above recommendation, the John Scott Legacy Premium and Medal be awarded to Geo. Westinghouse, Jr., of Pittsburgh, Pa., for his improvements in air brakes for railway trains, and that the Actuary be directed to make proper publication of the same.

The Actuary further reported from the Board the following resolutions, viz.:

Resolved, That the Committee on Exhibitions be directed to secure a guarantee fund of \$25,000, and thereupon publish notice of the intended Exhibition, and make proper preparations for the same.

Resolved, further, that the Committee on Exhibitions be enlarged, by appointment by the President, so as to consist of 100 members, including all the members of the Board of Managers.

On behalf of the Committee on Exhibitions, the Chairman, Mr. Wm. P. Tatham, then made the following report, viz.:

The Committee on Exhibitions respectfully report that, by virtue of a resolution of the Board of Managers, passed April 2d, 1874, it has become a joint committee of the Board and of the Institute at large, to consist, in all, of 100 members, appointed by the President of the Institute, and in this connection they recommend the adoption of the following resolution :

Resolved, That the members of the Institute furnish the President with names from which to select persons to fill up the Committee on Exhibitions to the number of one hundred.

The Committee further report that the Board of Managers having, at the same date, directed the Committee to secure a guarantee fund of not less than twenty-five thousand dollars, subscriptions have been solicited and obtained already to the amount of over thirty-five thousand dollars—the list being still open. Members desiring to subscribe will find the list with the Actuary.

The Committee further report that, the conditions required by the Institute and the Board of Managers having been fulfilled, they have issued the following notice, which they desire may be considered part of this report.

On behalf of the Committee,

W. P. TATHAM, *Chairman*.

The following notice is the one referred to :

The Franklin Institute of the State of Pennsylvania, for the promotion of the Mechanic Arts, will celebrate the fiftieth year of its foundation by an Exhibition of Arts and Manufactures, to be held in the City of Philadelphia, from the 6th to the 31st of October, 1874.

The exhibition will embrace all materials used in the Arts, in every stage of manufacture, from their natural condition to the finished product, and all tools, implements and machines, by which the gifts of nature are changed and adapted to the use, the comfort, or the enjoyment of mankind.

The Committee desire to make this Exhibition represent as fully as possible the mechanical improvements of the last half century—to which the Institute has so largely contributed—and all artisans, mechanics, manufacturers and inventors throughout the United States are cordially invited to contribute their best productions, and compete for the prizes which will be awarded to the most worthy.

Every facility will be afforded for exhibiting machines in motion. All persons desiring to exhibit are requested to make early application for floor space or steam power, or for room to exhibit boilers or engines in operation to drive the machinery of the Exhibition.

Foreign materials or manufactures, not entered for competition, will be welcomed and fairly exhibited.

Communications are to be addressed to *The Committee on Exhibitions Franklin Institute, Philadelphia, Pa.* Detailed information concerning the rules and regulations governing the Exhibition will be sent in reply.

By direction of the Committee on Exhibitions,

W. P. TATHAM, *Chairman*.

Philadelphia, April 14th, 1874.

It was, thereupon, moved that the report be accepted, and the reso-

lution therein contained approved. Carried. Nominations were therefore made, to the number of thirty-nine, of names to serve upon the Committee, in accordance with the resolution above approved.

The President next announced a paper, by Mr. Hector Orr, on Phosphor-Bronze. The same was a general treatment of the nature of the new alloy, its physical properties, and the status of its manufacture in the United States.

The Secretary then read his monthly report upon Novelties in Science and the Mechanic Arts.

Under new business, the President made a brief address to the meeting upon the life and character of the late Joseph Harrison, Jr., a former member and officer of the Institute.

Mr. Hector Orr moved that a committee of three, of which the President should act as chairman, be appointed to draft resolutions of respect to the memory of the deceased. Carried. The President, in accordance therewith, appointed Coleman Sellers, Hector Orr and Geo. F. Barker as members of the Committee.

Mr. J. Morgan Eldridge mentioned the fact that the Agricultural Society of Pennsylvania intended holding their Annual Fair about the same time as the Exhibition of the Institute, and dwelt upon the desirability and mutual advantage of having the two events transpire in Philadelphia. He moved the following :

Resolved, That the Secretary be instructed to communicate to the State Agricultural Society the fact that the Franklin Institute will hold an Exhibition of Arts and Manufactures during the coming fall, and suggest the mutual advantages which would result from holding the two exhibitions in the same city and at the same time.

The resolution was carried.

Mr. Hector Orr then moved the following :

Resolved, That with regard to the contemplated Industrial Exhibition, to be held this year, we respectfully suggest to the Board of Managers to restrict the privilege of members to their personal entrance thereto by their usual tickets.

Resolved, Further, that we urge upon our members a liberal purchase of single tickets, in order to promote the financial success of the said Exhibition.

The resolutions were referred to the Board of Managers, and the meeting adjourned.

WILLIAM H. WAHL, *Secretary*.

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No. 6.

EDITORIAL.

ITEMS AND NOVELTIES.

The Westinghouse Air-Brake in England.—Two important trials of the Westinghouse Air-brake have recently taken place in England; one on the 10th of April on the Midland Railway, and the other on April 29th, on the London, Chatham and Dover Railway. The former of these trials was for several reasons the more important of the two, it “having been organized, not by those interested directly in the brake itself, but by the Directors of the Midland Railway Company, the object being to arrive at some definite conclusions, independent of the inventor’s, as to the actual practical efficiency of the brake, under ordinary and extraordinary circumstances.” Twelve of the largest railway companies of England and France were represented, the experiments being conducted under the direction of a Committee chosen from among them. The results of these experiments, as well as the conditions under which they were performed, are given in the following official record as published in the *Times* and subsequently in the *London Engineer*.*

* The train consisted of engine, tender, two vans, and twelve passenger coaches, the total weight, including passengers, being 184 tons, as follows:—Engine, 33 tons; tender, 22 tons; vans, 16 tons; coaches, 108 tons; passengers estimated at 5 tons. The tender and guard’s vans had the air brake mechanism connected to the ordinary hand-slide brakes fitted with wood blocks. The coaches had cast-iron blocks; but the brake rigging on these was of three

Trials of the Westinghouse Continuous Air Brake on Midland Railway, between London (St. Pancras) and Bedford, on Friday, April 10th, 1874.

No.	Nature or kind of stop, &c.	State of rails.	Speed in miles per hour.	Gradient.	Time of stop from application of brake to absolute rest.	Distance run from application of brake to absolute rest.
					Seconds.	Yards.
1.	Ordinary station stop with air brake applied by driver, steam being first shut off.....	Dry	45	Up 1 in 160 and 320	18	253
2.	Ordinary station stop with air brake applied by driver, steam being first shut off.....	"	36	Up 1 in 400	15	273
3.	Steam shut off, air brake applied and engine reversed, but no steam applied. (The air brake practically stopped the train before the engine was reversed.).....	Slight rain.	43	Down 1 in 200	20	320
4.	Steam shut off, air brake applied, engine reversed, and steam applied in back gear. (Same as 3.).....	Dry	43	"	22	336
5.	Hand brakes applied on tender and guard's vans by signal of whistle from engine, steam being shut off.....	"	45	Up 1 in 173	65	880
6.	Hand brakes applied on tender and guard's vans by signal of whistle from engine, steam being shut off and engine reversed, but no steam applied. (6 and 7 had ample time to obtain benefit of reversing.).....	"	36	"	40	440
7.	Hand brakes applied on tender and guard's vans by signal of whistle from engine, steam being shut off and engine reversed, and steam applied in back gear.....	"	45	Up 1 in 176	53	660
8.	Air brake applied by guard in rear van, the driver on feeling brake shut off steam and applied the air brake from engine.....	"	56	Up 1 in 300	22	416
9.	Air brake applied by guard in front van, the driver on feeling brake shut off steam and applied the air brake from engine.....	"	43	Down 1 in 660	21	330
10.	Carriages were slipped, the air brake couplings broken away, and the portion left behind stopped by the application of the air brake from the rear van. (Eleven coaches and one van slipped.).....	"	56	Down 1 in 200	27½	Not taken
11.	Air brake applied from engine, and engine left in full forward gear with steam on (Steam reduced from 120 lb. to 110 lb. during stop; mean air pressure, 70 lb.).....	"	50	"	25	428
12.	Steam shut off and air brake applied as if slacked by signal, brakes released and steam re-applied. (The vibration due to the brakes was scarcely appreciable. Some of the carriages rode a little hard, but that was due to the blocks being new.)					
13.	Steam shut off and air brake applied; train brought to a stand; brakes released and train moved backwards; brakes again applied, train brought to a stand; brake released, steam re-applied, and train again moved forward, showing the action of brake as regards quickness of release, &c.....	"	50	Down 1 in 660	22	350
14.	Driver stopped upon receiving signal from carriage No. 203 (third coach from engine).....	"	32	Down 1 in 531	19	Not taken.
15.	Driver stopped upon receiving signal from rear van.....	"	23	Down 1 in 200	17	"
16.	Driver stopped upon receiving signal from front van.....	"	43	"	19	350
17.	Air brake stop by driver at fixed point, as for water. (Came to stop opposite box satisfactorily from fifty-three miles an hour.).....	"				
18.	Observations from Bank.—Train being run past with brake on, so as to show the action of the brake with reference to skidding of wheels, or otherwise. Some of the trailing wheels were skidded just before the train came to rest.....					
19.	Time taken to uncouple and couple two carriages with and without air brake. (Extra time taken to couple or uncouple brake pipes, 7 seconds.).....					
20.	Time taken by pump to restore pressure in reservoir after brake has been used. (To pump from 50 lb. to 80 lb. mean, 45 seconds; from atmospheric pressure to 50 lb., 57 seconds; to 60 lb., 71 seconds; to 70 lb., 87 seconds; to 80 lb., 107 seconds.).....					
21.	Stop with air brake with several of the couplings between the carriages disconnected. (Four couplings were disconnected on one side.).....	Dry	45	Up 1 in 200	26	325
22.	Stop with air brake after hole has been cut in one of the flexible tubes.....	Wet	38	Down 1 in 371	29	about 350

With reference to this trial, the *Engineer* says :

" We cannot call to mind any recent occasion when a question connected with the working of railways was raised, on which so many eminent railway authorities were present. The list of names shows how great is the interest taken in the brake by railway companies, and proves that the experiments were all conducted under the observation of most competent authorities." " It will be seen that the experiments tried, were the result of a consummate knowledge of the conditions which a continuous brake should fulfil, and we venture to think that no railway brake was ever so fully tested before, or ever came so satisfactorily through an ordeal of exceptional severity."

Engineering, in an able editorial on the Midland Railway trial, while admitting that " the apparatus worked with the utmost certainty and afforded every satisfaction so far as giving proof of perfect efficiency is concerned," regrets that the experiments fell so far short of accuracy, and failed to give the data for such exact deductions as the science of engineering demands, and says " the Westinghouse brake, admirable though its performance was, is, we have no hesitation in asserting, capable of far better things as regards promptness in stopping the train." " If speeds, times, and spaces," it goes on to say, " had been registered with the mathematical accuracy attainable by suitable mechanical contrivances, it would have been possible to have determined, not the result simply, but also how that result has been obtained." Even from the data secured, important conclusions may be drawn. The true measure of the efficiency of a brake being the mean retarding force exerted during the period of its application, this force may amount, the rails being in good order, to one-fifth or one-sixth of the insistent weight, or say 400 pounds per ton. The retarding force actually exerted in the recorded experiments is deduced separately from the times and the spaces upon the record, by means of the formulas :

$$r = \frac{28 v^2}{s} \text{ and } r_1 = \frac{115 v}{t}$$

kinds:—First, with the two length equalizing rock shaft hanging levers, and one block on each wheel; second, with tension bars without rock shaft, one block on each wheel; and third, with tension bars and blocks on both sides of each wheel. The tender and guard's brakes could be worked by hand lever in the usual way, independent of the air brake. The air brake fittings were so applied on the carriages that the brake blocks could be caused to act at the will of the driver, or either of the guards, on every wheel of the train, the engine wheels excepted. Apparatus for signalling between passengers and guards and driver was applied. The brake pipes between the carriages served for the signalling line of communication. The experiments commenced upon the train reaching Hendon station.

r being pounds per ton exerted by the brakes, frictional resistances, gradients, etc., in stopping a train going at the velocity v in miles per hour, in t seconds, or within s yards. Thus analyzed, the experiments yield the following results :*

Number of Exp't.		Deduced from Space. Pounds per Ton.		Deduced from Time. Pounds per Ton.
1	.	176	.	252
2	.	128	.	236
3	.	173	.	258
4	.	168 ?	.	236 ?
5	.	52	.	67
6	.	70	.	91
7	.	73 ?	.	84 ?
8	.	203	.	286
9	.	160	.	239
10	.	not taken	.	246
11	.	174+?	.	241+?
12	.	203	.	265
14	.	not taken	.	198
21	.	164	.	188

The most obvious fact here brought to view is, that "in every instance the mean retarding force per unit of space is smaller than it is when referred to units of time." Errors of observation can account for only a part of the difference.

"A little reflection will satisfy us that the identity in the results ordinarily deduced, whether time or space be the element given, arises simply from the fact that we are usually dealing with some force of uniform intensity, such as the force of gravity. Having advanced so far, we see at once that the difference in our results, after discounting errors of observation, indicates a lack of uniformity in the retarding force; and from the direction of the difference, we see that the latter must be comparatively small for some time after the application of the brakes, and increase in intensity as the velocity of the train diminishes. Referring to the first experiment, where the mean retarding force per unit of distance is 176 pounds per ton, it will be obvious that this condition would be satisfied if the retarding force increased uniformly yard by yard from the mere frictional resistances, or say 35 pounds per ton at the moment of the

* In experiments 5, 6 and 7, hand-brakes alone were used, taking effect upon from 20 to 25 per cent. of the entire weight of the train; in 10, the engine was detached, and all wheels braked; in all other experiments about 80 per cent. of the entire weight was controlled by the brakes. In 4 and 7, the engine was reversed; in 11, the steam was kept full on.

application of the brakes, until at the end of the space traversed it touched 317 pounds per ton. But though the space traversed is unaffected by the distribution of the retarding force, provided the mean value be unaltered, it is otherwise with the time. If the 176 pounds per ton had been uniform in intensity, yard by yard, we should have deduced 176 pounds, also, in lieu of 252 pounds, as the mean retarding force per second. The effect of the retarding force varying from 35 pounds to 317 pounds may be shown to be such that the mean retarding force per second will be about one third greater than the mean retarding force per yard; hence, upon the above hypothesis, it would follow that in our first experiment the former would be about 235 pounds, the latter being 176 pounds. There can be no doubt, therefore, that this increased value of the retarding force per second, as compared with the resistance per yard, indicates a want of promptness either in the handling or in the action of the brakes.

"The mean retarding force per yard in the instance of the nine air-brake experiments given in the table, will be found to average 172 pounds per ton. How much of this is due to frictional resistances, and how much to the brake, it is impossible to say; for it did not occur to any of the experimentalists to ascertain the proper time and distance of the train itself, when neither air-brakes nor hand-brakes were applied. Some years ago Mr. Bramwell found that the distance of 1800 yards was traversed by a train almost identical in composition and weight with the Midland train, in running freely from a speed of 40 miles an hour until it came to rest. By the first equation, the corresponding mean retarding force will be found to be 25 pounds per ton. If we adopt this value for the frictional resistances of the Midland train, and deduct it from the gross retarding force of 172 pounds, we obtain 147 pounds as the average retarding force exerted by the brakes per ton of train. Since the brakes acted upon 80 per cent. of the entire weight of train, this will be equivalent to 184 pounds per ton of the load on the braked wheels; and since, in order to reconcile the observed times and spaces, we must assume that the retarding force of the brakes increased gradually from *nil* up to double its average intensity, we are led to the conclusion that it must have been equal to about 370 pounds per ton toward the end of the run. Now, with the rails in good condition, as they were on Friday last, 370 pounds per ton is just the pressure that would make it impossible for any one to predict whether the braked wheels would revolve or skid. It is no matter for surprise, therefore, that the wheels themselves exhibited equal indecision—some revolved and some skidded."

The article then goes to consider a question much mooted among us, *i. e.*, the question of the inconvenience to passengers from too sudden a stop. It asserts that the effects of sudden stops are too much exaggerated, and, in proof of this, it states that if the feet be placed against the seat in front, the face to the engine, the train going at thirty miles an hour may be stopped in ten yards without throwing a greater pressure on our feet than they sustain in walking. Indeed as we may safely trust our knees and boots under a load double that

of the body, the train might be stopped in three or four yards without serious inconvenience. The question of bringing the train to rest in ten rather than twenty seconds, therefore, is a perfectly immaterial one so far as concerns the passengers' comfort, while it may be a vital one when their safety is involved. The article concludes as follows: "It is a theoretical possibility to pull up a train in half the distance averaged in the midland trials, and we have no hesitation in asserting that the Westinghouse brake is capable of doing anything that is theoretically attainable."

American Bessemer Works.—We are indebted to Mr. Alex. L. Holley for the following interesting facts concerning the present condition of the Bessemer steel industry in the United States. Since no one can speak upon this subject with more authority than he, we are glad to be able to put upon record in these pages these most gratifying facts, so far as this branch of metallurgic art is concerned. To this great success Mr. Holley has himself in no small measure contributed.

PRODUCT OF AMERICAN BESSEMER WORKS.

This has been steadily increasing, from various causes—better organization, better refractory materials, and chiefly numerous large and small improvements in mechanical details. In 1868 an output of 500 tons of ingots per month was barely reached in the best works; in 1870, the production at Troy and Harrisburg had risen to about 1700 tons per month, maximum. Early in 1872 the Harrisburg works turned out above 2000 tons per month, and for a year or more these and the Cambria works took the lead in this direction, the latter plant having run as high as 640 tons in one week. During 1873 the Cambria, Harrisburg, North Chicago and Joliet works averaged twenty-five to thirty heats of five tons each per twenty-four hours. During the week ending July 12, 1873, the Harrisburg works made 180 heats yielding 890 tons of ingots. The product of the Cambria works, the week ending Jan. 17, 1874, was 189 heats, giving 956 tons of ingots. During one twenty-four hours (Friday, Jan. 16,) forty-six blows were made. On Friday, February 13, 1874, the Troy works made fifty heats in twenty-four hours, yielding 267 tons of ingots. This is the most remarkable run on record. During the week ending April 4, the Troy works made 195 heats, yielding 972 tons of ingots, which is the largest week's work. In January, 1874, the Troy works made 2899 tons of ingots, and in April the North Chicago works made 3526 tons, which is the largest month's work.

These are all five-ton plants, consisting of two five-ton vessels, and accessories, and they work only eleven turns, or five and a half days per week.

The blooming trains employed at Troy, Cambria, North Chicago, Joliet and Bethlehem, are capable of rolling more than the average product of the Bessemer works. The first of these was erected at Troy in 1870; the feeding tables were first applied by Mr. Fritz to the Cambria mill, and have since been applied to all the mills, with some modifications. The Troy and Bethlehem mills roll ingots fourteen inches square, weighing over a ton, to make three rails each. The other mills at present roll twelve inch two-rail ingots.

The production of rails from blooms has been more uniform because the rail train was a highly perfected machine long before the Bessemer process was introduced. The Cambria mill has often produced over 1000 tons of rails per week, from a twenty-one inch train. Probably the best week's running on record, all things considered, was the Troy, ending April 25, 1874, viz., 1012 tons of sixty-two pound rails, in eleven turns, from nine furnaces and a twenty-one inch mill; of these there *was not one second quality rail*, and there were but $3\frac{1}{2}$ per cent of short rails.

The Geological Survey of the State of Pennsylvania.—

It is with great satisfaction that we record the fact that a new geological survey of the State of Pennsylvania has been ordered. The bill providing for it passed the Legislature on the 14th of May, and the same day received the signature of the Governor. After ordering the survey, the bill makes an appropriation of \$35,000 per annum for three years, to carry it into effect. The entire control of the survey is placed in the hands of a board of ten commissioners, together with the Governor, who is the *ex officio* president. This board is to have the appointing of the geologist-in-chief, is to fix the salaries of all the appointees, and to have the disbursing of all moneys. The geologist, when appointed, is to have the appointing of his assistants. He is to submit to the board a plan for the survey; if approved by them, it is to be carried out under his direction, and he is to be responsible for its execution. The board, as appointed by Gov. Hartranft, is composed as follows: Ario Pardee, Hazleton; Wm. A. Ingham, Philadelphia; Henry S. Eckert, Reading; Henry McCormick, Harrisburg; James Macfarlane, Towanda; John B. Pearce, Philadelphia; Robt. B. Nitson, Clearfield; Daniel J. Morell, Johnstown; Henry W. Oli-

ver. Pittsburg; S. Q. Brown, Venango county. We quote, with our cordial endorsement, the following remarks of U. S. Mining Commissioner Raymond, in the *Engineering and Mining Journal* of May 23d: "The names of these gentlemen afford a satisfactory guarantee that the duty entrusted to them will be conscientiously and intelligently performed. So far as the selection of a State geologist is concerned, their task will be easy. Professor J. P. Lesley is so generally acknowledged to be the right man for the place, that his appointment will be but the formal recognition and record of an overwhelming public sentiment in his favor. We congratulate the citizens of Pennsylvania that this great work has been taken up at a time when a great scientific worker, specially qualified for it and interested in it, is at hand to direct its execution."

Investigation of Prof. Thurston's Methods of Testing.—

We are gratified to be able to note that the Government has taken notice of the admirable testing apparatus of Professor Thurston, and has appointed a Commission to investigate it and its results. We take the following statement of it from the "*New York Tribune*," of May 4th:

The Secretary of the Navy has recently directed a Board, consisting of representatives of the Naval Academy and of the several Bureaus of the Navy Department, to examine the method of determining the useful qualities of iron, steel, bronze and other materials of construction recently devised by Prof. R. B. Thurston, of the Stevens Institute of Technology, and to report upon the Autographic Recording Apparatus made at the Institute. This Board, consisting of Chief Engineer Danby, Naval Constructor Hanscomb, Commander Meade, Prof. Greene, Lieutenant-Commander White, and other officers, visited the Stevens Institute at Hoboken on Saturday, and spent several hours inspecting the apparatus, discussing the new method, examining new designs, and making experiments. They also made a short tour of inspection through the buildings of the Institute, and in the afternoon returned to the Brooklyn Navy Yard in a steamer.

On the Devitrification of Glass.—Some curious specimens of crystallized glass were lately sent to M. Peligot by M. Viecleau, director of a glass manufactory at Blanzky, which were taken from a furnace which had been for some time out of use. These crystals differed completely, both in aspect and in mode of formation, from all the specimens of devitrified glass heretofore examined by M. Peligot. They were well developed prisms, twenty to thirty millimetres in length, and recalled in appearance crystals of sulphur and of bismuth

crystallized from fusion. Their analysis threw some light upon the obscure question of devitrification. While certain chemists maintain that this result is nothing but the separation in crystals of a definite silicate in the midst of the vitreous mass—a true segregation—others affirm that devitrification is a simple molecular change, in which the entire mass of the glass crystallizes, a phenomenon analogous to the change by which arsenous oxide becomes opaque. Peligot's analysis of these Blanzv crystals supported the former hypothesis, by showing that the crystallized portions differed in composition from the original glass. They contained no sodium, but had an excess of magnesium, corresponding to the pyroxene group. The crystals were altered by exposure to the air. They fused at a much higher temperature than the normal glass out of which they came. M. Peligot called the attention of the Academy to the large amount of magnesium present, suggesting its agency in the transformation.

Remarkable Motive Power.—A curious capillary experiment was devised by M. Lippmann some months since, which the author has recently utilized in a very ingenious way. The original experiment is thus described: Place in a saucer or in a large watch-glass a globule of mercury an inch or two in diameter, and pour upon it a little water acidulated with sulphuric acid and slightly colored with potassium bichromate. If now the mercury be touched laterally with the point of a needle, the globule will be observed to contract and withdraw itself from the needle, then to extend again to its primitive position. This brings it again into contact with the needle, the contraction is renewed, and so on indefinitely. When the globule is quite large it executes contorted and grotesque movements which are surprising to those who are not in the secret. The explanation of this phenomenon is found in the fact that under the joint influence of the iron and the bichromate, the mercury is successively oxidized and deoxidized, thereby producing an alteration in its capillary condition and causing the swelling and flattening. This oxidation and deoxidation may also be effected by an electric current. The globule is seen to swell up or to flatten, according as it is connected with the negative and deoxidizing or with the positive and oxidizing electrode. It is this oscillating motion of the globule of mercury that M. Lippmann has utilized in his motor. It is constructed as follows: In a trough of glass two small cups are placed, full of mercury; in each of these moves a piston formed of a bundle of glass tubes. The trough is filled with acidulated

water, and the two masses of mercury are in communication with the electrodes of a battery in such a way that when the one contracts the other flattens. Consequently, when one of the pistons rises the other falls: and by simply transforming this reciprocating motion of the pistons into a rotary one, an electro-capillary engine of some hundredths of a kilogram-metre of power is readily obtained. In the machine actually constructed by M. Lippmann the fly-wheel made a hundred revolutions per minute.

The extremely feeble current needed to set this engine in action suggests its use as an indicator of currents too feeble to be detected by the ordinary instruments. Used in this way it would constitute an extremely sensitive electrometer. Indeed it might come in use for the reception of cable dispatches, which, as is well known, are sent by means of very feeble currents. Certain movements of the machine might correspond to certain predetermined characters or sentences, and in this way the dispatch might be easily deciphered. Though scarcely more than curious at present, these experiments of M. Lippmann are exceedingly interesting, and will undoubtedly in the future receive important applications.

Use of Fluor-Spar in Working Puddling Cinder.—According to the second of the laws of chemical reaction enunciated by Berthollet, when fluor-spar and coal are heated with a silicate of iron, carbonic oxide and silicon fluoride are produced, and pass off as gaseous products, while the iron is left behind entirely desilicified. In 1872, M. Maussier, a French engineer, took out a patent for applying this reaction to the treatment of slags rich in iron, particularly those from the puddling furnace. Enormous quantities of these slags fail of utilization because, although they contain sometimes as much as fifty per cent. of iron, yet, on account of their easy fusibility and the difficulty of their reduction, but a small proportion can be worked in the charge of the ordinary high furnace. Nor have the attempts hitherto made to work them specially been more successful. By the use of fluor-spar, however, according to the reaction above given, it is possible to obtain in the ordinary puddling furnace, the cast-iron hearth being covered with scrap iron and kept from fusion by artificial cooling, a true brown hematite by the oxidation of the desilicified iron. By adding hammer-scale to the bath, a true iron ore of determinate composition may be produced. If, in place of the oxidizing flame, the reducing flame of the Siemens or Ponsard furnace be em-

ployed, the iron produced upon the hearth may be cemented directly, so as to produce even a cast-iron. This may then be puddled directly, either alone or with the addition of a charge of spiegel, and, if desirable, in the mechanical puddler of Danks or Pernot. But, in whatever way treated or worked, the process yields metallic iron.

In the high furnace, the use of fluor-spar in the charge renders it possible to introduce very much larger quantities of puddling cinder successfully.

Limit of Elasticity in Glass.—In a series of researches upon the compressibility of gases, M. Cailletet has been led to study the resistance which glass tubes oppose to rupture. By an ingenious method he has determined exactly the amount by which the volume of a hollow cylinder of glass varies, either when compressed within or upon its exterior. In one experiment a tube of 55 cm. (21.7 in.) long and 17 mm. (0.7 in.) in diameter, was crushed by an outside pressure of 77 atmospheres. One-half this pressure sufficed to break it when exerted upon the interior. When the glass is very thick, so as to resist pressure of 400 or 500 atmospheres, it suffers no permanent set. Upon this fact, M. Cailletet has constructed a manometer, at once simple, delicate and precise.

Franklin Institute.

HALL OF THE INSTITUTE, May 20th, 1874.

The meeting was called to order at the usual hour, with Vice-President Bloomfield H. Moore in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at their stated meeting held May 13th, donations to the Library had been received as follows :

Proceedings of the American Philosophical Society, Vol. 13, June to December, 1873. From the Society.

Proceedings of the Literary and Philosophical Society of Liverpool during the Sixty-second Session, 1872-73. From the Society.

Proceedings of the Scientific Meetings of the Zoological Society of London for the year 1873—Part 1, January to March, and Part 2, March to June. From the Society.

Annales de Chimie et de Physique, December, 1873, Vol. 30, and January, 1874, Vol. 1. Paris. From the Editor.

Bulletin de la Société d'Encouragement pour l'Industrie nationale, for December, 1873, and January, 1874. Paris. From the Society.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences, Index for Vol. 76 and Vol 77, Nos. 21 to 26. Paris, 1873. From the Academy.

Transactions of the American Philosophical Society, Vol. 15, Part 1, 1873. Philadelphia. From the Society.

Das Gebirge um Hallstadt. Eine Geologisch-Palæontologische Studie aus den Alpen, Part 1. Von Edmund M. v. Majsvar. Vienna, 1873. From the K. K. Geologischen Reichsanstalt.

Verhandlungen d. K. K. Geologischen Reichsanstalt, Berichte vom 31st July and October, 1873. Vienna, 1873. From the K. K. Geologischen Reichsanstalt.

Jahrbuch d. K. K. Geologischen Reichsanstalt, Vol. 33, July—December, 1873. From the same.

Zeitschrift des Architekten und Ingenieur Vereins zu Hannover, Vol. 19, Part 3. Hannover, 1873. From the Society.

Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains; being the Fifth Annual Report of Rossiter W. Raymond, U. S. Mining Commissioner. Washington, 1873. From the Author.

Treatise on the Method of Government Surveying as Prescribed by the U. S. Congress, &c. By Shobal & Clevenger, U. S. D. S. Washington, 1874. From S. V. Clevenger.

Report of the Proceedings of the Meteorological Congress at Vienna. Protocols and Appendices. Translated from the Official Report. London, 1873. From the Meteorological Committee of Royal Society.

Fourth Annual Report of the Board of Commissioners of Public Charities of the State of Pennsylvania. Harrisburg, 1874. From the Board of Public Charities.

Annales des Mines, Vol. 4, Part 6, 1874. Paris. From the Editor.

Monthly Report of the Chief Engineer of the Manchester Steam Users' Association, December, 1873; also, the Annual Report of the Committee of Management to the Members of the Association Manchester, 1873. From the Association.

Proceedings of the Royal Geographical Society of London, Vol. 18, No. 2, 1873. From the Society.

Proceedings of the Royal Society, Vol. 21, Nos. 146, 147; Vol. 22, Nos. 148 to 150. London. From the Society.

Journal of the Society of Arts, Vol. 22, Nos. 1111—1114. London. From the Society.

Die Fauna der Schichten mit Aspidoceras Acanthicum. Von Dr. M. Neumayer. Vienna, 1873. From the K. K. Geologischen Reichsanstalt.

Sundry English Patent Specifications for the Years 1872, 1873, with Abridgements. London. From the Hon. Commissioners of Patents.

The Actuary likewise reported the following recommendation from the Board :

Resolved, That, at the next meeting of the Institute, the following be offered as an amendment to the By-Laws, Article 2, Section 7 : Members whose yearly dues are in arrears for three years shall be considered as having resigned, and the Actuary is directed to strike their names from the list of members.

The proposed amendment was laid over for consideration for one month.

The Actuary then reported the minutes of the several standing committees.

The special committee appointed by the President to draft a minute expressive of the sense of the Institute upon the death of Joseph Harrison, Jr., then presented the following report :

Your Committee to whom was referred the preparation of a minute commemorative of the life of active usefulness of our late fellow member, Joseph Harrison, Jr., report that he was born in the city of Philadelphia September 20, 1810. At the age of fifteen he was regularly apprenticed to learn the trade of machinist, and under two masters (the first having failed) he terminated his indentures with credit, and entered upon his duties as a journeyman machinist with a reputation for industry and ability as a workman. In 1837 he was taken into the firm of Garret Eastwick & Co., and in 1843, in connection with his partner, Mr. Eastwick, and Mr. Winans of Baltimore, he made a contract with the Russian Government to build engines in Russia with Russian workmen. The contract was for five years and amounted to the sum of three millions of dollars. In a strange land and knowing nothing of the language, surrounded by people ready to take advantage of any weakness, under a government proverbial at that time for the corruption of its under officials, the work was begun and so well done as to lead to other and more important contracts, and to cause the American firm to be respected by the people of all lands with whom they had dealings.

In 1852 he returned with his family to his native city to expend his ample fortune in beautifying his home. Many and beautiful are the monuments of his taste in architecture, and in all are seen the peculiarities of his mind trained in the mechanic arts. About him he gathered treasures of art, and proud was he of the production of the pencil and chisel of native artists. In his love

of the fine arts is shown the refined cultivation needed for success as an artisan. Mr. Harrison was an earnest advocate of the city owning galleries of painting and sculpture, to be at all times open to all who would study the beauties of art. He would have had our working people familiar with high art, and for this end he would have had that art as free to them as is the air we breathe.

At home he conceived the idea of improvements in the construction of steam boilers that have made his name famous. Your committee deem it a work of supererogation to repeat in these halls what Mr. Harrison has done in this direction. Others may have enunciated the principles that he carried into practice; to him and to him alone is due the credit of establishing, as a manufacturing interest, steam generators in the strength of the smallest part, or unit of which lies the strength of the structure as a whole. Following in his footsteps, others will surely reap a rich reward from what he has begun, and even if his invention, as conceived by him, should pass out of use, the fundamental principle will remain as the foundation for others to build on. One at least of those to whom you have assigned the task of commemoration knew him during all the years he labored to perfect his invention, and knew him as an earnest mechanic, as a lover of the mechanic art, as a kind and loving father and a sincere christian gentleman—knew him in his strength, when he longed to benefit his fellow-men. Suddenly a painful malady beset him, and for five years only those who were with him much realized how great a sufferer he was and with what patience he bore the pangs of his dreadful affliction. On March 27th, 1874, death ended his suffering. Few men beginning life so humbly have risen to higher honors in the ordinary walks of life.

His connection with this Institute began in 1834, when he was elected a member, and for three years he sat in the Board of Management. The *Journal of the Franklin Institute* contains among its volumes several valuable contributions from his pen. As in the case of others of our members who have passed away, we recognize in his mind that growth with his years and opportunities that rewards all seekers after knowledge. When it is known that he had never been required to write a composition at school, had never written a letter until he was a man grown, the ability of each one to educate himself becomes manifest in his progress in knowledge.

From his life history we may draw the best of lessons as to what can be gained by steady industry and due application to all that is needed to insure mental growth.

Your Committee, in conclusion, offer the following :

Resolved, The Franklin Institute tenders its earnest sympathy to the family of the late Mr. Joseph Harrison, Jr., in their affliction, and in conveying to them the record of this minute they wish to express the high esteem in which they will ever hold his memory.

All of which is respectfully submitted,

COLEMAN SELLERS,	} Committee.
HECTOR ORR,	
GEORGE F. BARKER,	

The report as read was received, and the resolution therein contained was adopted.

In this connection Mr. J. B. Knight, on behalf of Mr. Alexander Purves, presented the following communication :

The resolution adopted by the Franklin Institute at its last meeting, to make proper mention of the life and death of our late member, Joseph Harrison, Jr., brings to my mind a circumstance that occurred between him and myself, of which I give the substance. It will show Mr. Harrison's sentiments and the drift of his mind when he was a young man.

Many years ago, when Mr. Harrison was closing out his business preparatory to going to Russia, I bought from him a lot of machinery and metals. The bill came to more than we expected and more than I had money to pay with. I asked him to trust me for a part of the bill, promising to pay in a short time ; he hesitated, and saying that I was a stranger, perhaps would not pay, but sell myself for the balance due. After some conversation about my just beginning business and the small amount of my capital, he consented. I paid him promptly at the time agreed upon. Mr. Harrison was much pleased, and said he "did not intend to hurt my feelings in what he had said the other day about selling, but he *did mean* that thousands of beginners and others failed of success in business through the want of promptness and faithful discharge of their engagements. The neglect to pay an amount promptly, however small, makes a doubt. If not paid at all, the party sells himself for a trifle and never will succeed. To be truly successful in business or in any sphere of life one must have the faith and confidence of his fellow-men, which is far more valuable than his capital and can only be had by prompt and faithful performance and strict integrity in all engagements, without which neither man nor nation can prosper permanently."

Our conversation, I might say his lecture, was quite extended. Among the most important matters, he held that "man must be true to himself ; he must not make engagements without reasonable prospects that he can fulfill them, nor must he be too timid, for then he will accomplish nothing, but should use that reasonable judgment which becomes a man." Mr. Harrison was plain spoken ; he regarded fraud in any form, such as short weight, overreaching or deception in an agreement, or bribery, to be, in plain English, stealing, which, although not known to others, is known to one's-self, and hangs like a dead weight upon the soul, dragging him down from that self reliance and confidence of manhood which alone gives him fortitude to meet as a man all the affairs of life. Under ordinary circumstances there is plenty of room and means in the world for a man to earn his own bread without stealing that which belongs to others, if he will but use his mind and energies. In our country he must be a miserable being (or a most unfortunate one) who cannot by his own determination thrive and lay by something for the future ; *failure* is generally our own fault. Mr. Harrison said he was going to Russia among strangers. He felt confident of success, although he had but little more money to operate with than I had, but *success or failure*, he would come back without degrading himself by fraud in any way. If he did not succeed as he expected, he would return to the anvil and the lathe at home.

My own experience in life would verify the sentiments of Mr. Harrison—that strict integrity in all things is the only way to success, usefulness, honor, man-

hood and a conscious happy life. I wish that young men could be deeply impressed with Mr. Harrison's noble sentiments; they are universal, not that Mr. Harrison's life can be imitated, for that cannot be—it was his—but they can build their own life by the same *great virtues of manhood* and make a success or failure by their own doings. *No one knows* what he may be called upon to do in the shop, in the building of structures, or even in the affairs of state. In every place *we can make an effort*. Without manly virtues we will certainly fail. Mr. Harrison's was an extraordinary success. An apprentice boy, without money or friends, in a far-away country, among strangers, he inspired confidence and faith, which enabled him to do mechanical works and build structures which are an honor to any one. He lived a most respected, useful and honored life, and died in the possession of millions.

A. PURVES.

The Chairman next introduced Mr. Calvin Pepper, of New York, who read a paper on the subject of Silicon-Iron and Steel, in the course of which the speaker elucidated his process of manufacturing these materials, and gave an account of their properties. In conclusion, he announced that the subject was at present before the Committee on Science and Arts, for examination and report.

Mr. Horace McMurtrie, of Boston, next followed with a paper on Steam Boiler Explosions no Mystery, a carefully prepared essay, in which the author claimed, from the evidence of statistics, that the explosion of steam boilers was in every case assignable to a simple and preventable cause. The paper was discussed by Messrs. Wiegand, Lovegrove, Le Van and the author.

Mr. Wm. B. Le Van followed with a paper descriptive of a late steam boiler explosion which occurred in this city.

The Secretary then presented his Monthly Report on Science and the Mechanic Arts, in the course of which specimens of cloth and paper manufactured of asbestos, in Glasgow, Scotland, were exhibited.

Mr. Alex. Bary next described and illustrated, with the aid of the stereopticon, a design for the proposed Centennial Exhibition building, as submitted by A. B. Bary, G. R. Pohl and J. H. Cofrode, engineers and architects.

Six additional names of members to serve upon the Committee on Exhibitions, were offered by Mr. Hector Orr, and ordered to be added to the list.

The meeting was thereupon adjourned.

WILLIAM H. WAHL, *Secretary*.

Civil and Mechanical Engineering.

THE METRIC SYSTEM IN OUR WORK-SHOPS; WILL ITS VALUE IN PRACTICE BE AN EQUIVALENT FOR THE COST OF ITS INTRODUCTION?*

BY COLEMAN SELLERS.

In compliance with the invitation of the General Supervisory committee, as expressed through your Secretary, that, as an associate member of the American Railway Master Mechanics' Association, I should prepare a paper on some subject relating to the objects for which this association has been organized, I have decided to call your attention to a matter which may before many years be forced upon you, and which you should be prepared to consider with care; I allude to the proposed introduction, by legislative enactment, of the French system of measurement, known as the metric system.

It is not my intention to discuss the subject in all its bearings, for it is a theme requiring more pages of manuscript than I would care to inflict upon you. But I will state in as few words as possible how the proposed change would be likely to affect the workshops of the land. It is now about three-quarters of a century since the metre was first made the legal standard of length in France, and during that time it has been adopted by other countries, either in full or in part; so that the advocates of its universal adoption claim that the proportion of the population of the globe already enlisted in its use numbers 420,000,000. Hence they argue that, for the sake of a uniform metrological system all the world over, England and the United States of America should also adopt it to the exclusion of our present system of inches, feet, etc.

Many of our leading colleges are making the metric system the method of measurement in all their teaching, with a view to sending their graduates into the world as advocates of what to them seems so perfect a system.

There can be no doubt that it is very desirable to have uniformity, not only in regard to measurements of all kinds, but also in money, as such uniformity would certainly facilitate trade and advance our

* A paper read at the Chicago Meeting of the American Railway Master Mechanics' Association, May, 1874.

knowledge of the works of other countries. Those who use the metric system in all scientific matters find it wonderfully well adapted to facilitate calculation. In spite of its long names it is easily understood by persons of moderate education, and can be used even by those who have no idea of the Latin and Greek words from which the names are derived. If the world, as we know it in our arts and trades, was to be made over again, and we were obliged to adhere to ten as the base of our arithmetic, it would doubtless be a good thing in some respects, but very unhandy in more respects, as not admitting of binary division. I have heard it declared by men of high intelligence that its introduction now is retarded only by prejudice, by the unwillingness of people to give up what they are used to, and the necessity of learning certain new rules and methods of thought. Unfortunately, may be, there is something more than these objections that will retard its introduction. The change involves the expenditure of money—of very large sums of money. When this cost is presented to our minds, we may well consider whether the results to be obtained will warrant the expenditure.

The late Senator Sumner was its earnest advocate, and at one time was determined to push the adoption of the metric system. He said to one of our most distinguished scientists, "I am content to have it legalized in 1870 and to have its use then optional, but in 187— I would make its use compulsory." The gentleman to whom he addressed himself asked if he had well considered what a tax such a measure would impose on the country. "We have now in use," he said, "in all kinds of trades, the pound as our unit of weight, and Messrs. Fairbanks and other scale makers have for years been making platform scales with beams graduated to pounds. The edict that abolishes the pound will necessitate a change in all these machines for weighing. All their beams must be removed and reg graduated to the new unit at an enormous expense." He instanced the change in the weight unit as the one most readily made, as it in the main affects perishable property only.

On February 5th, 1870, a resolution was passed in the United States Senate, that "The President be requested, if not incompatible with the public interests, to invite a correspondence with Great Britain and other foreign powers with a view to promote the adoption, by the legislatures of the several powers, of a common unit and standard of an international gold coinage." etc. In accordance with the spirit of this resolution, a dispatch was prepared by the Department of

State.* In this paper, after recounting the requirements of such a unification in coinage as shall not prejudicially affect our interests, it says:—

“It is to be observed that an identity in the measures of value in the different countries will not completely attain the beneficent results which are sought, unless there be also an identity in weights and measures. * * * * In commercial transactions an identity in measures of value would be of comparatively little use if unaccompanied by identity in the measures of the quantities to which those values are applied. There would still be a necessity for the intervention of an expert to shift the expressions of the measures of quantity, from the terms used in one country, to those in use in the other. The resolution of the Senate does not contemplate the extension of this correspondence to these points; nor in my judgment would it be desirable to do so.

“It would probably not be difficult to induce the people of different countries to adopt a common standard of weights and measures so far as perishable property is concerned. At first the adoption of unaccustomed systems might cause inconvenience and discontent, but if they should prove to be better than the old ones, and if they should have the further advantage of being common to several countries which possess a common standard of value, and which have extended commercial relations, it is probable that the inconvenience would be patiently submitted to, in view of the greater benefits to be derived from the change.

“But it seems to the Government of the United States that a forced change in the measures of distance, as applied to imperishable property and the permanent investment of capital, may be attended with more serious inconvenience. Thus while it may be practicable to establish a new standard of length-measure for articles of international commerce, such as textile fabrics which are consumed and do not remain, it may be more difficult to make the same change in the standard for permanent values. A few examples will demonstrate the difficulties that would probably attend a change in such measures in this country. * * * *

“It is the custom in the United States to lay out all towns and cities in regular quadrangles, and to divide each quadrangle into an even number of lots with an even number of feet. This has been found a convenient mode of dealing in town and city lots and in town and city houses. To make an arbitrary change, which should abolish these measures and substitute different ones in their places, involving the use of fractional numbers, would occasion great inconvenience, and might check the dealings in this species of property, and cause a loss to those who happened to be holders at the time of the change.

* See U. S. Report on Foreign Relations for 1870.

Again, the whole system of titles in those states which have been created out of the public domain rests upon government survey, whose results are expressed in the English mile and its subdivisions, rods, feet and inches. To substitute a different measurement would be a work of serious magnitude.

“Again,” and this is what most seriously affects our interests, “the manufactories of the country are filled with machinery, whose delicately adjusted parts, measured in feet, inches and component parts of the inch, work together in one grand whole, which is in its turn combined in the same system of measures. To produce this machinery, thousands of shops are filled with costly plants, adjusted upon the same scale, whose delicate operations often require a nicer determination of measurement than can be obtained without mechanical aid. To transmute these measurements, so delicate and accurate, from the present system into a new one, would appear to be an almost endless labor, if indeed it be a possibility.”

To show how clearly these statements express the difficulties that would attend our adoption of the metric system, I will call your attention to certain conditions of the mechanic arts in America, perhaps not fully appreciated by those who think the change is one of education only.

Eli Whitney, whose name has always been associated with the invention of the cotton gin, started, in 1798, an establishment for the manufacture of small arms on the principle known as the interchangeable system, carried out by the use of hardened jigs or forms of the same shape as the parts to be produced, thereby making all parts of guns alike and interchangeable one with another. He introduced the use of milling, by means of revolving cutters, those intricate shapes needed in gun work. When he proposed to Thomas Jefferson, then Secretary of State in Washington's Cabinet, to make an arm modelled after the approved French Charville flint-lock, in which all parts of all guns should be interchangeable, he was ridiculed by both French and English ordnance officers. The government aided Mr. Whitney, and in 1800 the present Springfield Armory was established, and Mr. Whitney's inventions and system put in force there. It was not until 1855 that the English War Department was forced to adopt the same system, importing a large amount of machinery from America for that purpose.

This was not the only branch of the mechanic arts that was benefitted by this interchangeable system. America, contending with high labor, has been forced to exercise ingenuity, and make labor-saving machines produce cheaper work. This could only be done

by carrying the interchangeable system into other processes of manufacture; and American clocks, watches, sewing machines and all the countless small articles of hardware, are made by machinery, each piece like the others. Recognizing the absolute need of this interchangeable quality in everything manufactured, but few trades exist in this country that do not avail themselves of its advantages. Gradually, separate and distinct manufacturing establishments have come to use the same standards and to make their production interchange one part with another. Witness the various devices making up what is known as line shafting, as also all the screws and fittings for steam, gas and water pipes, and now the so complete recognition of the American system of screw threads for bolts and nuts. The primary object of this Association may almost be said to be to introduce uniformity in all parts of the great railroad system of the United States. There is no country in the world where the value of uniformity in the devices used in common by all mechanics, is so fully recognized as in this land of ours. What has been done in this direction, and what is being done now, is founded on the inch as the unit of measurement in the machine shop.

The machine shop, however, is not independent of other trades, and it is necessary to a proper understanding of our subject, that we have a clear perception of the nature of this inter-dependence. Machines made of metal have parts cast and parts forged. Wrought-iron is procurable in bars of certain merchantable sizes. When rolling mills are obliged to make round iron, differing in diameter from these merchant sizes, the price per pound is increased, as special appliances and extra care is required. So the mechanical engineer conforms his proportions to the procurable sizes of bar iron, and uses the iron, as far as possible, without the expense of re-forging into other sizes. This is noticeably the case in regard to rounds and squares. The tools and appliances in the machine shop have in time been made to conform to these sizes, and are all expressed by the division of the inch into halves, quarters, eighths and sixteenths. All the gearing in the country, all the patterns of cog wheels, are spaced in the teeth, by pitches, measured in inches, and the binary division of the inch, $\frac{1}{4}$ ", $\frac{1}{2}$ ", 1", $1\frac{1}{2}$ ", etc., pitch; or, in number of teeth to the inch in diameter, called in practice per-inch wheels, as 12, 10, 8, or 6 per-inch, meaning so many teeth to each inch in diameter; as, for instance, a wheel three inches in diameter cut to ten per-inch, has thirty teeth, *i. e.*, $10 \times 3 = 30$. The patterns of gear wheels, in some instances,

form no insignificant part of the stock in trade of large machine shops, and the immense number of wheels now spaced to pitches in inches must necessitate the continued use of them, whether we call the pitch 1" or 25·38 mm.

When the metric system was introduced into France, all machine work was done by hand; the planing machines for metals, and all the various appliances known as machine tools, with the exception of the turning lathe, were almost unknown. Sizes expressed in one measurement or another were of less moment than now. I dare say many of my hearers remember the time when the rule of thumb was the mechanic's rule; when the "boss" chalked out on the carpenter's bench a thing about "so big," to be made in metal, and then some other thing was made to fit it; at such time it mattered little what standard was used as measure. While French savants were laboring to build up this decimal system of interchangeable measures, the better class of American mechanics were solving the problem of making machinery with interchangeable parts. I am perfectly willing to concede that there are workshops in the land, in which the change from the inch to the metre could be made at very little cost, simply because these shops are furnished with no special devices for measurement even at this day; such drills and mandrils as they may have are altered in size at the whim and fancy of the workmen. The proprietor of one of this class of shops asked me, not many years ago, if we had a pattern of spur wheel of some pitch and diameter; and when I asked him if he had measured the diameter at pitch line of wheel, he wanted to know what the pitch line meant. Metres would do for that man quite as well as inches. Such machinists, in stating dimensions, use the terms full and scant to express fractions which might be quite readily stated with accuracy; sometimes, however, indulging in the extra expression of a "leetle full scant" for very nice measurement.

A well furnished establishment is provided with gauges, mandrils, reamers, standard drills and boring tools, as well as all other appliances needed for accurate work made to certain fixed sizes, and in most shops these special tools amount in value to large sums of money. The nomenclature of the sizes of these tools, as expressing the work they are expected to do, is part of their economical use; thus, an inch reamer is expected to make a hole exactly one inch in diameter, and no great effort of memory is needed to designate its size; but this same inch reamer will make a hole 25·38 millimetres in diameter—which is the same size expressed in French measurement.

In the machine shop the unit of measurement is the inch—it is not the foot nor the yard—we express in inches all measurements of objects that may sometimes be made less than one foot in size. Thus, pulleys are rated as 5" or 10" or 72" in diameter. Boilers are spoken of as being 36", 42" or 48" diameter. Car wheels are 30, 32 or 36 inches in diameter. For all calculations in the drawing rooms we use the inch and its decimal divisions, corresponding exactly with our dollars and its division into halves, quarters, eighths and sixteenths. As in money, we say half a dollar or fifty cents with equal facility, so in measurement we have the half inch or .50 inch, each as expressive of size as the other.

The advocates of the substitution of the metric system for our favorite inch, say we have only to give new names to these sizes. This we can do; we can call our inch 25.38 millimetres, or, if we prefer, we can call it the twenty-five hundred and thirty-eight hundred-thousandths of a metre; or we can call it two centimetres, five millimetres and thirty-eight hundredths of a millimetre. They say, further, we can make a slight change in our sizes, and dropping the fractions of the millimetre use the even millimetre; thus our familiar inch would be replaced with the twenty-five millimetre size, which is a decidedly "scant" inch. As an appendix to this paper, I give a list of all our usual fractions of the inch, and our even inches up to twelve inches expressed in metric measurement.

Let me now explain how this change of size is to be brought about; that is, what we must do if we are obliged to give up our inch. The drawings of all our machines—drawings that have accumulated through many years, and are expressive of enormous sums of money and the best mechanical talent of the land—must be gone over and all the sizes changed. To express in millimetres the present sizes in inches would never do—it would involve us in a sea of fractions that would drive any ordinary brain crazy. No, we must alter all the sizes to the nearest even millimetres. Thus, some dimensions, marked three inches, must be changed to seventy-six millimetres, .14 of a millimetre smaller than three inches, and some other size must be altered to make up the loss. Think of the labor involved in such a change, and you will not require me to say what such a change will cost. But it is said new work can be made to the new sizes, and the old sizes can be continued for the time. This is exactly the point I wish to reach in the statement of trouble and cost involved.

Drawings made twenty-five years ago are in use to-day, and draw-

ings made during each of the succeeding years are many of them in use, and the tools and gauges are perfected to manufacture machines in accordance with these drawings. To-day we begin new drawings with the new dimensions; the change can be readily made in the drawing room. It requires no vast amount of education to substitute one drawing scale for another. We send the new drawing into the machine shop and then the cost begins; all our old tools of fixed sizes, all our old gauges, are wrong; new ones must be made, and we must run the risk of mistakes from the simultaneous use of two standards. Now, for your information, I have taken the trouble to make a careful estimate of the cost involved in altering or making new (for we dare not alter all the taps, dies, reamers, mandrils, gauges and the other guides for the workmen in an establishment fully equipped for say two hundred and fifty machinists), and the sum foots up to \$27,000—more than one hundred dollars for each man employed. This does not contemplate any change in existing drawings; should we attempt to alter all the drawings, I cannot see how, in the same establishment, the change could be made at a cost less than one hundred and fifty thousand dollars. What do you think of such a change at such a cost? Would it not indeed paralyze this industry?

President Barnard, in his very able report in favor of the metric system, or rather in favor of some unification of measurement, says, "I do not expect that this system will make its way in the world against the will of the people of the world. I do not expect that our people, and I do not desire that any people, shall be coerced into receiving it by the force of 'imperial edicts' or by the terror of bayonets. What I do expect is that they will sooner or later welcome it as one of the greatest of social blessings. What I do expect is that they will one day become conscious of the many inconveniences to which they are subjected from the anomalous numerical relations which connect, or rather, we might say, disjoin, the several parts of their present absurd system; inconveniences which they have learned to endure without reflecting on their causes or suspecting that they are unnecessary in the nature of things; and that when fully at length awake to the slavery in which they live, they will burst the shackles and rejoice in the deliverance which the metric system brings. This cannot take place, of course, until the people are thoroughly informed."

Business men in all times look at the cost of each change. School men see beauties in the metric system and train their pupils as its

earnest advocates, but they do not count the cost. If it is needful to make the change it can be made more cheaply to-day than to-morrow, more cheaply this year than next. While the schools educate the people to see its advantages, the money value of the permanent plant to be changed is increasing more rapidly than the uninformed on this subject can appreciate. Changes in such things as standards of measurement have been made in other countries, and changes, if needful, can be made now; but the question may in all fairness be asked, is it needful in this instance? So far as my own experience goes, having had the opportunity to use the inch and millimetre in one and the same establishment for many years, using one with as much familiarity as the other, my choice is most decidedly in favor of the inch as the unit of measurement in the machine shops and on the railroads of the country. That others think so too, in regard to one question in mechanics, let me prove by an example. Many years ago Mr. Whitworth attempted to establish a uniform system of screw threads based on the inch as its unit. His scheme met with such success that now, with the exception of France only, all the metre using peoples of the world have adopted the Whitworth system, and it has even been largely adopted in this country. It is considered better and more convenient than the French system. According to Mr. Whitworth's system, a half inch screw should have twelve threads to the inch; to express this in the metric language, a bolt 12.7 millimetres should be 2.12 millimetres pitch. I have said business men count the cost before making changes in matters of habit or use, but when they can be shown that they will be gainers by the change they give in to it heartily. This same example of screw threads will serve as an illustration. Mr. Whitworth's system of screw threads was already introduced in all the principal workshops of Europe and in many in this country. But a better system was presented to the Franklin Institute, a system based on such simple laws that, given the formula with no existing original to copy, any careful workman can originate a given thread that will match those in use. After an exhaustive debate on the subject of its introduction by the various departments of our government, and a careful consideration on the part of our mechanical associations, it came to be adopted as the United States standard. It was adopted at considerable expense because it was believed to be an improvement on existing practice. We have still to keep up our old taps and dies for repair work, but no mechanic has deemed the expenditure involved in the change other than judicious.

To enable you at your leisure to consider the value of our inch unit as compared with the French system, I have added to this paper (appendix B) a list of some of the prominent metric screw systems as compared with the United States standard and the Whitworth.

Recognizing the advantages offered by the decimal system in money, we accept the dollar and cents in preference to the pound sterling of England. We now have in use, in land surveying in the country, the chain and its decimal division. In city measurements the foot and its decimal division is also used, and in mechanics we have the inch as our unit, with its division into one-hundredths for calculation, and into vulgar fractions where its written expression is rendered plainer thereby. I have in this paper made no attempt to discuss the merits of the metric system as carried out in all its perfection, through measures of distance, surface, solidity and weight. This has been considered by abler men than I am. My object has been to present to you the cost involved in the change, and to show that something more than want of education strengthens the hands of Englishmen and Americans in resisting any change in their methods of measurement. By the law of our land, those of our citizens who choose to use the metric system can do so, and their so doing will meet all requirements of the law; but the standard of the land is, for our purposes, the inch, and I for one should be sorry to see it abolished.

If, as I am informed, some of our schools of science see fit to make their method of teaching dependent on the metre and its divisions, to the exclusion of the ordinary nomenclature of the land, their wisdom may well be questioned. We need educated engineers, but we need them educated in our mode of thought. The universities of the land are awake to the need of scientific education, and our sons are sent to them that they may learn what will be of the most use to them in active life. We wish them to learn the languages of other leading lands, but we insist that they shall know their own language. We would have them read the scientific languages also, but if for good reasons we choose to retain our technicalities, deeming them more convenient for our use, we also insist that they shall know how to use them in our business relations.

Impressed, as I am, with the insurmountable difficulties in the way of a change in our unit of measurement, even if that change was desirable, I cannot help thinking that, if the hypothetical New Zeal-

APPENDIX B.
COMPARISON OF SCREW THREADS IN USE.

FRANCE.								ENGLAND.				AMERICA.			
Pitch in millimetres.								Whitworth.				U. S. Standard.			
Diam. in mm.	French Railroads.	Denis Poulot.	Bodmer.	Vignole d'Armen-gaud.		Ducom-mun.		Diam. in inches.	Diam. in millime-tres.	Pitch in millime-tres.	No. of threads per inch.	Diam. in inches.	Diameter in milli-metres.	Pitch in millime-tres.	No. of threads per inch.
3			0.5			3	0.5								
4			0.5			4	0.75								
5			0.83	5	1.4	5	0.75	$\frac{3}{16}$	4.7	1.058	24				
6			0.83			6	1	$\frac{1}{4}$	6.4	1.270	20	$\frac{1}{4}$	6.4	1.270	20
7		1.50	1.00			7	1.25								
8	1.50	1.50	1.00	7.5	1.6	8	1.25	$\frac{5}{16}$	7.9	1.410	18	$\frac{5}{16}$	7.9	1.410	18
9		1.50	1.25			9	1.5								
10	1.50	1.50	1.25	10	1.8	10	1.5	$\frac{3}{8}$	9.5	1.585	16	$\frac{3}{8}$	9.5	1.585	16
12	1.50	1.75	1.47			12	1.75	$\frac{7}{16}$	11.1	1.815	14	$\frac{7}{16}$	11.1	1.815	14
14		1.75	1.73	12.5	2.0			$\frac{1}{2}$	12.7	2.120	12	$\frac{1}{2}$	12.7	1.95	13
15	2.00	2.00	1.73	15	2.2	15	2	$\frac{5}{8}$	15.9	2.309	11	$\frac{5}{8}$	14.26	2.120	12
18	2.00	2.00	2.00	17.5	2.4	18	2.5	$\frac{3}{4}$				$\frac{3}{4}$	15.6	2.309	11
20	2.00	2.50	2.50	20	2.6	20	2.5	$\frac{7}{8}$	19.1	2.54	10	$\frac{7}{8}$	19.1	2.54	10
23	2.50	2.50		22.5	2.8	23	3.0	$\frac{15}{16}$	22.2	2.820	9	$\frac{15}{16}$	22.2	2.820	9
24			2.78												
25	3.00	3.00		25	3.00	25	3.0	1	25.4	3.175	8	1	25.4	3.175	8
26			2.78												
28	3.00	3.00	3.125			28	3	$1\frac{1}{8}$	28.6	3.629	7	$1\frac{1}{8}$	28.6	3.629	7
30	3.00	3.50	3.125	30	3.4	30	3.5								
32	3.00	3.50	3.58			32	3.5	$1\frac{1}{4}$	31.8	3.629	7	$1\frac{1}{4}$	31.8	3.629	7
34			3.58												
35	3.50	4.00		35	3.8	35	4	$1\frac{3}{8}$	34.9	4.225	6	$1\frac{3}{8}$	34.9	4.225	6
37						37	4								
38	3.50	4.00	4.18					$1\frac{1}{2}$	38.1	4.225	6	$1\frac{1}{2}$	38.1	4.225	6
40	4.00	4.50		40	4.2	40	4								
42			4.18			42	4.5	$1\frac{5}{8}$	41.3	5.080	5	$1\frac{5}{8}$	41.3	4.61	$5\frac{1}{2}$
45				45	4.6	45	4.5	$1\frac{3}{4}$	44.5	5.080	5	$1\frac{3}{4}$	44.5	5.08	5
46			5.00												
47						47	5	$1\frac{7}{8}$	47.6	5.650	$4\frac{1}{2}$	$1\frac{7}{8}$	47.6	5.08	5
50			5.00	50	5	50	5	2	50.8	5.650	$4\frac{1}{2}$	2	50.8	5.650	$4\frac{1}{2}$

ander, when he has done contemplating the ruins of St. Pauls, from the sole remaining vestige of London bridge, in the far-off distance of the future, shall seek from the ruins of a mighty city to learn the nature of a nation's greatness, and shall measure its length and its breadth, as did Prof. Piazza-Smyth the Pyramids, he will find its unit of measurement to have been the inch.

APPENDIX A.

RELATIONS OF THE METRE AND THE INCH.

Millimetres.	Inch.	Inch.	Millimetres.	Millimetres.	Inch.	Inch.	Millimetres.	Inches.	Millimetres.	Centimetres.	Metre.	Inches.
1	·03937	$\frac{1}{16}$	1·58	13	·51182			2	50·76	1	·01	·39371
2	·07874			14	·5512	$\frac{9}{16}$	14·26	3	76·14	2	·02	·78742
3	·11811			15	·59056	$\frac{5}{8}$	15·85	4	101·52	3	·03	1·18113
4	·15748	$\frac{1}{8}$	3·17	16	·62994			5	126·9	4	·04	1·5748
5	·19685	$\frac{3}{16}$	4·73	17	·66931	$\frac{11}{16}$	17·43	6	152·28	5	·05	1·9685
6	·23622			18	·70868			7		6	·06	2·3622
7	·2756	$\frac{1}{4}$	6·34	19	·74805	$\frac{3}{4}$	19·02	8		7	·07	2·756
8	·31497	$\frac{5}{16}$	7·92	20	·78742	$\frac{13}{16}$	20·60	9		8	·08	3·1497
9	·35434	$\frac{3}{8}$	9·51	21	·82679	$\frac{7}{8}$	22·19	10		9	·09	3·5434
10	·39371			22	·86616			11		Decimetre. Metre. Inches.		
11	·43308			23	·90553	$\frac{15}{16}$	23·77	12				
12	·47245	$\frac{7}{16}$	11·09	24	·9449			1	25·38	1	·1	3·9371
		$\frac{1}{2}$	12·68	25	·98424	1	25·38	2	304·56	2	·2	7·8742
								3		3	·3	11·8113
								4		4	·4	15·7484
								5		5	·5	19·6855
								6		6	·6	23·6226
								7		7	·7	27·5596
								8		8	·8	31·4976
								9		9	·9	35·4339

1 metre = 39·371 in.

[Entered according to the act of Congress, in the year 1873, by John Richards, in the office of the Librarian of Congress at Washington.]

THE PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

By J. RICHARDS, Mechanical Engineer.

(Continued from page 262.)

THE ARRANGEMENT OF ENGINEERING ESTABLISHMENTS.

The first and, perhaps, the most important matter of all in founding engineering works is that of arrangement. As a commercial consideration affecting the cost of manipulation, and the cost of handling material the arrangement of an establishment may determine in a large degree the profits that may be earned, and upon this matter of profits depends the existence of such works.

Aside from the cost or difficulty of obtaining ground sufficient to carry out plans for engineering establishments, the diversity of their arrangement that is met with is no doubt owing mainly to a want of reasoning from general principles in the preparation of plans.

The similarity of the operations carried on in all works directed to the manufacture of machinery, and the kind of the knowledge that is required in planning and conducting such works, would lead us to suppose that at least as much system would exist in machine shops as in other manufacturing establishments, which is certainly not the case in America, and hardly the case in Europe.

There is, however, this difference to be considered: that whereas most other establishments are arranged at the beginning for a specific amount of business, machine shops generally grow up around a nucleus, and are gradually extended as their reputation and the demand for their productions increase; besides, the variety of operations required in an engineering establishment are apt to lead to a confusion in arrangement, which is too often promoted, or at least not prevented, by the want of a true estimate of the cost of handling and moving material.

The material consumed by an engineering establishment consists mainly in iron, fuel, sand and lumber. These articles or their product is, during the processes of manipulation, continually approaching the erecting shop, from which finished machinery is discharged after its completion. This constitutes the erecting shop, as a kind of focal centre of the works, which should be the base of a general plan for arrangement. This established, and the foundry, smithy, finish-

ing and pattern shops, regarded as feeding departments to the erecting shop, it follows that the connections between the erecting shop and the other departments should be as short as possible and such as to allow free passage for the material and communication between the managers and workmen. These conditions would suggest a central room for erecting, with the various departments for casting, forging and finishing, radiating from the erecting shop like the spokes of a wheel, or, what is nearly the same, branching off at right angles on either side and at one end of a hollow square, leaving the fourth side of the erecting room to front on a street or road, permitting free exit for the machinery when completed.

By an arrangement of this kind the material is received on the periphery, as we may say, the product discharged in the centre, and the communication between departments is the most direct that it is possible to have. By observing the plans of the best establishments of modern arrangement, especially those in Europe, the apprentice will see that this system is approximated in many of them, especially in establishments devoted to the manufacture of some special class of work.

Handling and moving material is in fact the leading object to be considered in the arrangement of engineering works. The constructive manipulation can be watched and estimated, and faults detected by comparison, but handling, like the designs for machinery, is a more obscure matter, and may be greatly at fault without the defects being apparent to any but those who are highly skilled.

Presuming an engineering establishment to consist of one-story buildings, and the main operations to be conducted on the ground level, the only vertical lifting to be performed will be in the erecting room, where the parts of the machines are assembled. This room should be reached in every part by an over-head travelling crane, that can not only be used in turning, moving and placing the work, but in loading it upon cars or wagons.

Castings, forgings, and general supplies of the erecting room can be easily brought from the other departments on trucks without the aid of the motive power; so that the erecting and foundry cranes will do the entire lifting duty required in any but very large establishments.

The auxiliary departments, if disposed about an erecting shop in the centre, should be so arranged that material which has to pass through two or more departments can do so in the order of the processes, and

without having to cross the erecting shop. Casting, boring, planing, drilling and fitting for examples, should follow each other and the departments be arranged accordingly.

Whenever a casting is moved twice over the same track or moved and returned over the same course, it shows fault of arrangement, and useless expense. The same rule applies to any kind of material. A great share of the handling about an engineering establishment is avoided if the material can be received on a higher level than the working floors; if, for instance, coal, iron and sand is received from railway cars at an elevation sufficient to allow it to be deposited where it is wanted by its gravity, it is equivalent to saving the power required to raise it again to such a level if the material was delivered on the ground, for if the coal, iron or sand is not to be raised it has to be moved horizontally and piled up, which amounts to the same thing in the end.

It is not proposed to consider the details of shop arrangement further than to furnish a clue to the general principles that should be consulted in devising plans of arrangement.

Such general principles are much more to be relied upon than even experience in the arrangement of shops, because all experience must be gained in connection with special conditions that often warp and prejudice the judgment and leads to errors in forming plans where the conditions are different from those where such experience was gained.

GENERALIZATION OF SHOP PROCESSES.

Having thus far treated of such general principles and facts connected with practical mechanics as might properly precede and be of use in the study of actual manipulation in the workshop, we come next to casting, forging, and finishing, with other details that involve manual as well as mental skill, and to which I will apply the term "processes," for want of one more applicable.

As these shop processes or operations are more or less connected, and run one into the other, it will be necessary at the beginning to give a short summary of them, stating the general object of each, that may serve to render the detailed remarks more intelligible to the apprentice as he comes to them in consecutive order.

Designing or generating the plans of constructing machinery may be considered the leading element in engineering manufactures or machine construction, the one to which all others are subordinate, both in order and importance, and is that branch to which engineering knowledge is especially directed.

Designing consists, first, in assuming certain results, and, secondly, in conceiving of mechanical agents to produce these results.

It comprehends the geometry of movements, the disposition and arrangement of material, the endurance of wearing surfaces, adjustments, and symmetry; in short, all the conditions of machine operation and machine construction. This subject will be again treated of in another section relating to shop processes.

Drafting, or drawing, as it is more commonly called, is a means by which mental conceptions are conveyed from one person to another; it is the language of mechanics, and takes the place of words, which are insufficient to convey mechanical ideas in an intelligible manner.

Drawings represent and explain the machinery to which they relate as the symbols in algebra represent quantities, and in a degree admit of the same modifications and experiments to which the machinery itself could be subjected if here already constructed.

Drawings are also an important aid in developing designs or conceptions. It is impossible to conceive of, and retain in the mind, all the parts of a complicated machine and their relation to each other without some aid to fix the various ideas as they arise, and keep them in sight for comparison; like compiling statistics, the footings must be kept at hand for reference, and to determine the relation that one thing may bear to another.

In the workshop, the objects of drawings are to communicate plans and dimensions to the workmen, and to enable a division of the labor so that the several parts of a machine may be operated upon by different workmen at the same time, and to enable classification and estimates of cost to be made, and records kept.

Drawings are in fact the base of shop system, upon which depends not only the accuracy and uniformity of what is produced, but also, in a great degree, its cost.

Complete drawings of whatever is made are now considered indispensable in the best regulated establishments: yet we are not so far removed from a time when most work was made without drawings, but what we may realize their importance by contrasting the present with the system that existed but a few years ago, when to construct a new machine was a great undertaking, involving generally many experiments and mistakes.

Pattern making relates to the construction of wooden models for the moulded parts of machinery.

Pattern making involves a knowledge of shrinkage and cooling

strains, the manner of moulding and proper position of pieces, when cast, to insure soundness in particular parts.

As a branch of machine manufacture, pattern making requires a large amount of special knowledge, and a high degree of skill; for in no other department is there so much that must be left to the discretion and judgment of the workmen.

Pattern makers have to understand drawings thoroughly, in order to reproduce them on the trestle boards with allowance for shrinkage; they must also understand moulding, casting, fitting and finishing, and should, as a department of machine manufacture, rank next to designing and drafting.

Founding and casting relates to forming parts of machinery by pouring melted metal into moulds, the force of gravity alone being sufficient to press or form it into even complicated forms.

As a process for shaping such metal as is not injured by the high degree of heat required in melting, moulding is the cheapest and most expeditious of all means for shaping or forming material, for forms of regular outline, while the importance of moulding in producing irregular forms is such that without this process the whole system of machine construction would have to be changed.

Founding operations are divided into two classes, known technically as green sand moulding, and loam or dry sand moulding; the first, when patterns or duplicates are used to form the moulds, and the second, when the moulds are built by hand without the aid of complete patterns.

Founding involves a knowledge of mixing and melting metals such as are used in machine construction, the preparing and setting of cores for the internal displacement of the metal, cooling and shrinking strains, chills, and many other things that are more or less special, and can only be learned and understood from actual observation and practice.

Forging relates to shaping metal by compression or blows when it is in a heated and softened condition; as a process it is an intermediate one between casting and what may be called cold treatment.

Forging also relates to welding or joining pieces together by sudden heating that melts the surface only, and then by forcing the pieces together while in this softened or semifused state.

Forging also includes, in ordinary practice, the preparation of cutting tools, and tempering them to various degrees of hardness as the nature of the work for which they are intended may require; also

the construction of furnaces for heating the material, and mechanical devices for handling it when hot, with the various operations for shaping, which, like casting, can only be understood when seen.

Finishing and fitting relates to giving true and accurate dimensions to the parts of machinery that come in contact with each other and are joined together or move upon each other, and consists in cutting away the surplus material that has to be left in founding and forging, because of the heated and expanded condition in which the material is treated in these last processes.

In finishing, the material is operated upon at its normal temperature; in which condition it can be handled, gauged or measured, and will retain its shape after it is fitted.

Finishing comprehends all operations of cutting and abrading, such as turning, boring, planing and grinding, also the handling of material; it is considered the leading department in shop manipulation, because it is the one where the machinery is organized and brought together. The fitting shop is also that department to which the drawings especially apply, and other preparatory operations are usually made subservient to the fitting.

Shop system may also be classed as a branch of engineering work; it relates to the classification of machines and their parts by symbols and numbers, to records of weight and the cost of cast, forged and finished parts, and apportions the cost of finished machinery among the different departments of the works.

Shop system also includes the maintenance of standard dimensions, the classification and cost of labor, with other matters that partake both of a mechanical and a commercial nature.

In order to render their study more easy for the apprentice, I will, in treating of shop processes, change the order in which they are named in the summary. Designing, and many matters connected with the operation of machines, will be more easily learned and better understood after having gone through with what may be called the constructive operations, such as involve manual skill.

MECHANICAL DRAWING.*

Drawing may in some regards be said to bear the same relation to mechanics that writing does to literature, but the analogy is by no means

* The 'substance' of this article appeared in a former number of the JOURNAL last year, but its revision and connection with the series from which it was taken, for the first publication, will warrant its reproduction. W. H. W.

complete ; a person may copy a manuscript or write from dictation about what he does not understand, but a mechanical draftsman cannot make drawings of a machine he does not understand ; at least he can not do so in the true capacity of a draftsman and a mechanic.

Geometrical drawing is not an artistic art so much as it is a constructive mechanical one ; displaying the parts of machinery on paper, is much the same in principle and just the same in practice, as measuring and laying out work in the workshop.

Artistic drawing is addressed to the senses, geometrical drawing is addressed to the understanding. Geometrical drawing may, however, include artistic skill, not in the way of ornamentation, but to convey an impression of neatness and completeness, that has by common custom been assumed among engineers, and which conveys to the mind an idea of competent construction in the drawing itself, and also in the machinery which is represented.

Artistic effect in drawings is easy to learn, and through a desire to make pictures, the beginner is often led to neglect that which is more important in the way of accuracy and a judicious arrangement of the drawing.

It is easy to learn "how" to draw, but is far from easy to learn "what" to draw ; let this be kept in mind, not in the way of discouraging effort in learning "how" to draw, for this must come first, but in order that the objects and true nature of the work will be understood.

The engineering apprentice as a rule, has a desire to make drawings as soon as he begins his studies, and there is not the least objection to his doing so, in fact there is a great deal gained by illustrating movements and the details of machinery at the same time of studying the principles. Such drawings, if made, should always be finished and carefully inked in, and memoranda made on the margin of the sheets with the date and the conditions under which the drawings was made. The sheets should be of uniform size, not too large for a portfolio, and carefully preserved, no matter what their character.

An apprentice who will preserve his first drawings in this manner, will some day find himself in possession of a souvenir that no consideration would cause him to part with.

For an outfit procure two drawing boards, forty-two inches long and thirty inches wide, to receive double elephant paper ; have the boards plain without cleets, or any ingenious devices for fastening

the paper, and made from thoroughly seasoned lumber at least one and one-fourth inches thick.

Two boards are required, so that one may be used for sketching and drawing details, which if done on the same sheet with elevations, dirties the paper, and is apt to lower the standard of the finished drawing by what I will term bad association.

Details and sketches should, when made on a separate sheet, be to a larger scale than on the elevations; by changing from one scale to another the mind is schooled in proportion, and the conception of sizes and dimensions is more apt to be based upon the finished work than the drawing itself.

In working to regular scales, such as half-eighth or sixteenth size, it is a good plan to use a common rule, instead of graduated scales; there is nothing more convenient for a mechanical draftsman than to be able to resolve dimensions into various scales, and the use of a common rule for fractional scales trains the mind so that the computations come naturally and after a time almost without effort.

Use a plain T square with a parallel blade fastened on the side of the head, but not inbedded into it; in this way the set squares can pass over the square head in working at the edges of the drawing; it is something strange that a drafting square should ever have been made in any other manner than this, and still more strange that people will use squares that do not allow the set squares to come near to the edge of the board.

A bevel square is often convenient, but should be an independent one; a T square that has a movable blade is never fit for general use; combinations in drafting instruments, no matter what their character, should be avoided; such combinations, like those in machinery, are generally mistakes, and effect just the reverse of what is intended.

For set squares, or triangles, as they are sometimes called, no material is so good as guttapercha; such squares are hard, smooth, impervious to moisture, and contrast with the paper in color; they will also wear longer than those of wood.

If wood squares are used, pear wood is best, because of its flexibility. A coat or two of shellac varnish improves such squares by making them smooth and preventing their derangement by moisture.

For instruments, avoid everything of the elaborate or fancy kind; such sets are for amateurs, not engineers. It is best to procure at first only such instruments as are really required, of the best make, and then to add others as necessity may require; in this way experience will often suggest modifications.

One pair each of three and one-half inch and five inch compasses, two ruling pens, two pair of spring dividers, for pen and pencils, a triangular boxwood scale and common rule, and a hard pencil, are the essential instruments for machine drawing.

At the beginning, when "scratching out" will probably form an item in the work, it is best to use Whatman's paper, or the best roll paper, which, of the best manufacture, is quite as good as any other for drawings that are not water-shaded.

In mounting sheets that are likely to be removed and replaced, for the purpose of modification, as working drawings generally are, they can be fastened very well by small copper tacks driven along the edges at intervals of two inches or less; the paper can be very slightly dampened before fastening in this manner, and if the operation is carefully performed the paper will be quite as smooth and convenient to work upon as though it were pasted down; the tacks can be driven down so as to be flush with, or below the surface of, the paper, and will offer no obstruction to the squares.

If a drawing is to be elaborate, or is to remain long upon the board, the paper should be pasted down. To do this, first prepare the mucilage, and have it ready at hand with some slips of absorbent paper about one inch wide. Dampen the sheet on both sides with a sponge, and then apply the mucilage along the edge, for a width of one-half inch; then set the edge of the board on the floor, so that it will lean against the desk at steep angles. In this position the paper can be applied without assistance. Then, by placing the strips of paper along the edge and rubbing over them with some smooth, hard instrument, the edges are pasted firmly to the board; the paper slips taking up a part of the moisture from the edges, which are longest in drying. If left in this condition, the centre would dry first, and the paper be pulled loose at the edges by contraction before the paste had time to dry. It is therefore necessary to pass over the centre of the sheet with a wet sponge at intervals until the edges adhere firmly, when it can be left to dry, and will be tight and smooth. In this operation much depends upon the judgment of the learner, and much will be learned by practice. One of the most common causes of trouble in mounting is in not having the mucilage thick enough; when thin, it is absorbed by the wood or the paper, and is too long in drying; it should be as thick as it can be applied with a brush, and made from clean gum Arabic or tragacanth; glue is not so good.

Thumb-tacks are of but little use in mechanical drawing except for

the most temporary purposes, and can very well be dispensed with altogether; they injure the drafting boards, obstruct the squares, disfigure the sheets.

To be continued.

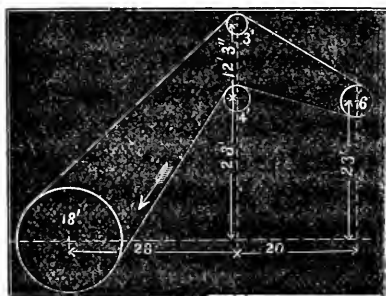
BELTING FACTS AND FIGURES.

By J. H. COOPER.

(Continued from Vol. LXVI, page 410.)

Mr. H. W. Curtis, of this city, furnishes the following:

"We have at our works a 20-inch single leather belt, 167 ft. long, having a $3\frac{1}{2}$ -inch single leather belt cemented and riveted on its outside face at either edge, and transmitting the power of a 20-inch diam., 48-inch stroke, horizontal Corliss engine. It is arranged to give power directly to three shafts, each in a separate room, from which the power is further conveyed, by means of vertical belts, to the other parts of the factory. The lower fold of this belt extends from the fly-wheel over a pulley 4 ft. in diameter (see cut), situated



28 ft. from and 23 ft. above the horizontal line of the engine. The upper fold is carried 12 ft. 3 in. higher, and over a pulley 3 ft. in diameter, situated directly above the 4-foot pulley.

"The main receiving pulley is 6 ft. diameter, situated in an adjacent building, 48 ft. horizontally distant, having its center on a level with that of the 4-foot pulley.

"The fly-wheel is 18 ft. diameter, and runs 60 revolutions per minute, giving a velocity to this belt of 3392 ft. per minute, and was calculated to give 125 horse-power on the three pulleys collectively, in the proportion of 80 on the 6-foot pulley, 24 on the 4-foot pulley, and 21 on the 3-foot pulley. This would make 70.6 square feet of belt per minute per horse-power on the 6-foot pulley, 235.55 square

feet on the 4-foot pulley, and 292.2 square feet on the 3-foot pulley. If considered as a 27-inch belt, it would be working at 61 square feet per minute per horse-power.

"This belt has worked up to 125 horse-power, as proven by indicator cards taken from the engine, which subjects the lower or drawing fold of the belt to a tensile strain of 1216 lbs., or 45 lbs. per inch of width, allowing 7 inches for the $3\frac{1}{2}$ -inch strips, making the belt equal to one of a single thickness 27 inches wide.

"This belt has been running nine months; its upper fold is very slack, the longest span is 50 ft., at an angle of 45° , having a sag of 20 in. to 24 in., and it has given entire satisfaction during that time. We have also three other belts, with similar strips on their outer faces. These belts were all tried 'single' at first, but would not do the work required of them. The first is 20 in. wide, taking power from a pulley 4 ft. in diameter to 3 ft. in diameter, situated 12 ft. 10 in. directly above. The next is 16 in. wide, taking the greater part of the power from the 20-inch belt, by means of a 40-inch pulley, to one 24 in., situated 12 ft. 6 in. directly above. These belts were put on at the same time as the main belt, and after trying them five days, running only part of the machinery, and that with insufficient power, we thought it best to try the strips. The result was that with the strips they have driven all the machinery connected with them, giving no trouble whatever, and have not been tightened more than once in the time named above.

"The next is an 8-inch belt, driving a pump, the piston of which is 4 in. diameter, 12 in. stroke, is double acting, and makes 24 strokes per minute. The pulley on the crank shaft of pump is 22 in. diameter, and this is driven by a 7-inch pulley, situated nine feet below and five feet from the perpendicular line of the pump; both pulleys are covered with leather. The pump lifts water 12 ft., through a $2\frac{1}{2}$ -inch pipe, and forces it 80 ft. more of vertical height through 123 ft. of 2-inch pipe.

"A single leather belt, 8 in. wide, was first applied, but it would not drive the pump at all. It was thoroughly tried, by being drawn so tightly that it parted at one of the splices in a few minutes. It was then provided with strips, one on each edge, $1\frac{1}{2}$ in. wide, and put on again, driving the pump successfully. It runs about three hours each day, and has not been tightened in five months.

"From the above results it is plain to see that our experience with belts of this character has been very satisfactory thus far; and we do

think that belts made heavier and stronger on their edges conform to the convexity of pulleys better, and that the same weight of leather will drive more and keep straighter than in any other form. We do not, however, recommend belts, strengthened by narrow strips on their outer faces, for running at a high speed over very small pulleys; in such places only light belts, of an even thickness, should be used."

A Sheet Iron Belt—A lathe used for turning rolling-mill rolls, compound geared, has a 48-inch pulley on it; this is driven by an 18-inch pulley, on the counter shaft, which makes 120 revolutions per minute, and is 8 ft. from the 48-inch pulley, measured from center to center. Both pulleys of iron smoothly turned on faces.

A 7-inch double leather belt was used on these pulleys, but would slip when the turning-tool became dull.

This belt was replaced by one made of Russia sheet iron, same as used for stove pipes and parlor stoves, and was rivetted together in the ordinary way; it was seven inches wide and was two inches longer than the leather belt. This extra length made up for the want of elasticity in the iron.

During one year's steady run this iron belt could not be slipped, even when a heavy "cut" on a 25-inch roll was taken, which broke a "Sanderson" steel tool having a section of $2 \times 2\frac{1}{2}$ inches, a cutting surface of $2\frac{1}{2}$ inches, a feed of $\frac{1}{8}$ inch per revolution, and an overhang of 4 inches.

JOHN SPIERS, Worcester, Mass.

New Proof of the Metallic Character of Hydrogen.—MM. Troost and Hautefeuille have lately completed an important research relative to the compounds formed by hydrogen with certain metals, particularly potassium and sodium. They find that hydrogen unites definitely with both of these metals, forming compounds containing two atoms of the metal to one of hydrogen. Heated to 200° with hydrogen, potassium unites with it, producing a compound which is decomposed again at 900° . Sodium also unites with hydrogen at 200° , but the resulting compound is completely decomposed at 400° . Both these hydrides present all the characters of amalgams; they have a metallic lustre and show the general physical appearance of a metal. This fact furnishes an additional proof of the metallic character of hydrogen, these compounds being quite analogous to the palladium hydrides discovered by Graham. Potassium and sodium hydrides are true alloys, so far, at least, as their physical properties are concerned.

Chemistry, Physics, Technology, etc.

ON THE RUSSIAN COALS FROM THE BASIN OF THE RIVER DON, INVESTIGATED BY MESSRS. SCHEURER-KESTNER AND MEUNIER-DOLFUS.

By Chief Engineer ISHERWOOD, U. S. Navy.

The carboniferous strata of the basin of the River Don, in Russia, contain immense deposits of coal, which are now being mined, and will doubtless soon be advantageously substituted for English coal along the shores of the Black and Mediterranean Seas. Some of this coal has an exceptional purity, yielding, even when burned in large quantities, only two or three per centum of ash. Its qualities have been carefully investigated by A. Scheurer-Kestner and Charles Meunier-Dolfus, who have accurately determined its ultimate chemical composition and its total calorific effect when consumed in oxygen, employing for the latter purpose an improved Favre and Silbermann calorimeter. They made similar determinations, also, for a Russian lignite, from Toula, in the Government of Riazan.

The calorific effects thus obtained have an interest additional to their use in determining the commercial value of the coal, as furnishing a test of the reliability of that law of Dulong which assumes the calorific effect of coal free from hygroscopic moisture to be the sum of the calorific effects of its combustible elements less the portion of hydrogen required to form water with the whole of its oxygen. The correctness of this law had previously been extensively investigated, by Messrs. Scheurer-Kestner and Meunier-Dolfus, for many of the coals of the upper Rhine, for two Welsh coals, and for six lignites of Bohemia, the lower Alps and the mouths of the Rhone. The result was that the coals gave experimentally a calorific effect from three to twelve per centum higher than was obtained by calculation according to Dulong's law. Of the six lignites, one gave experimentally five per centum less calorific effect than was due to the calculation; but the remaining five gave a greater calorific effect than was due to the calculation by respectively 3.0, 12.7, 20.9, 13.5 and 8.3 per centum.

The Russian coals of the Don differed from the coals just cited in giving experimental calorific effects nearly the same as were derived from calculation. For instance, of the three coals examined,

one gave an experimental calorific effect 0·8 per centum higher than the calculated one; another gave an experimental calorific effect 0·9 per centum lower than the calculated one; while the experimental calorific effect of the third was 1·5 per centum higher than that due to the calculation. To these may be added an anthracite examined by Messrs. Favre and Silbermann, which gave experimentally the calorific effect due to the calculation. Some cellulose examined by Messrs. Scheurer-Kestner and Meunier-Dolfus gave a similar result; that is to say, the calorific effect given by calculation according to Dulong's law was obtained by experiment in the calorimeter.

Messrs. Scheurer-Kestner and Meunier-Dolfus are confident of the accuracy of their calorific determinations to within one per centum, but the experimental inquiry is a difficult one, and the direct result requires somewhat uncertain corrections of much magnitude for disturbing causes. Again, should the ultimate analyses of the coals be but very slightly erroneous in assigning too little hydrogen, and it is almost impossible to so completely isolate it as to ascertain its full quantity, the inferiority of the calculated to the experimental calorific effect would nearly vanish.

A notable difference between the coals and lignites is that the coals gave experimentally a calorific effect not only greater than the calculated calorific effect according to Dulong's law, but greater than is due to the sum of the calorific effects of the elements without deduction of the hydrogen required to form water with the oxygen; while the lignites (with one exception), although giving experimentally greater calorific effects than are due to the calculation, gave less calorific effects than are due to the sum of the calorific effects of the elements.

If, however, the accuracy of the experimental results be admitted, then, starting from the fact of the equality of the experimental and calculated calorific effects of cellulose, and assuming lignite and coal to be formed principally from cellulose, the conclusion is reached, as regards heat of combustion, that cellulose, lignite and coal form a series in which the cellulose, when transforming into lignite and into coal, *undergoes a modification accompanied by absorption of heat*, the absorption being much more considerable for the coal than for the lignite.

The problem is one of the highest industrial importance, and its satisfactory solution requires much more extended trials to be made by other apparatus and by other experimenters. Any difference that

may thus be finally established between the experimental and the calculated results will probably be but very small, and confined almost entirely to the volatile portion of the coal which, even if composed of the same ultimate elements in the same proportion, may have them combined into very different proximate principles, requiring different quantities of heat for their volatilization and decomposition. In the meanwhile, the results of calculation according to Dulong's law, which is one based on rational considerations, may be accepted as giving at least *relative* determinations with sufficient accuracy for the purposes of practice.

The following table contains the results of the investigation of the ultimate composition and calorific effects of the coals from the basin of the Don, and of the lignite from Toula. The calorific effects are given, first, experimentally, for the crude coals and lignite; that is to say, for one pound of these substances, including their hygroscopic water and ash. Next, experimentally, for one pound of what remains of the coals and lignite after deduction of their hygroscopic water and ash. Then, by calculation, for the sum of the calorific effects of the ultimate elements of one pound of what remains of the coals and lignite after deduction of their hygroscopic water and ash. And, finally, by calculation according to Dulong's law, for one pound of what remains of the coals and lignite after deduction of their hygroscopic water and ash.

The calorific effects are expressed by the number of pounds of water, at the temperature of 32 degrees Fahrenheit, which would be raised one degree Fahrenheit under the pressure of 29.92 inches of mercury, by the heat developed during the complete combustion of one pound of the substance, supplied at the temperature of 32 degrees Fahrenheit, and having the products of its combustion cooled down to the same.

The percentum by weight, and the character of the coke derived from the above coals by calcination in a retort, are as follows:

The Groucheaski anthracite gave 91 per centum of feebly agglomerated residuc.

The Mioucki coal gave 80 per centum of very hard coke.

The Galouboski coal gave 60 per centum of well agglomerated coke, but less tenacious than the preceding.

The lignite was brown in color, and broke into lamellated fragments, with sharp edges and conchoidal faces.

	Composition of the Coals of the Don, in per centum of their weight.						Composition of the Lignite of Toula, in per centum of its weight.	
	Anthracite. Groncheaski.		Coal. Mioueki.		Coal. Galouboski.		Lignite. Toula.	
	Crude.	Less Ash and Water	Crude.	Less Ash and Water	Crude.	Less Ash and Water	Crude.	Less Ash and Water
Carbon.....	91.20	96.66	89.97	91.45	77.47	82.67	54.37	73.72
Hydrogen.....	1.27	1.35	4.43	4.50	4.75	5.07	4.49	6.09
Oxygen and Nitro- gen, with trace of Sulphur.....	1.88	1.99	3.98	4.05	11.48	12.26	14.89	20.19
Ash.....	1.57	.....	0.23	.....	1.42	.....	16.86	.....
Hygroscopic water...	4.08	.....	1.39	.....	4.88	.....	9.39	.....
Total.....	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Pounds of water, by experiment, raised 1° F. by one pound of the crude coal and lignite		Calorific effects.	Calorific effects.		Calorific effects.		Calorific effects.	
		14139	15383		13509		10429	
Pounds of water, by experiment, raised 1° F. by one pound of what re- mains of the coal and lignite after deducting ash and water.....		14866	15651		14433		13837	
Pounds of water, by calculation accord- ing to the sum of the calorific ef- fects of the ele- ments, raised 1° F. by one pound of what remains of the coal and lignite after ded- ucting ash and water.....		14899	16103		15181		14513	
Pounds of water, by calculation accord- ing to Dulong's law, raised 1° F. by one pound of what remains of the coal and lig- nite after deduct- ing ash and water		14742	15791		14227		12944	

The following table contains the composition and calorific effects of two first-class Welsh steam coals, with which the Russian coals will be brought in competition in the Black and Mediterranean Seas. The Welsh coals were investigated by Messrs. Scheurer-Kestner and Meunier-Dolfus with the same apparatus and in the same manner as in the case of the Russian coals; the results, therefore, are strictly comparable.

Name of Coal.	Composition of the Welsh Coals, less Ash and Hygroscopic Water, in per centum of their weight.			Calorific effect, by experi- ment, in pounds of water raised 1° Fahr. by one pound of what remains of the coal after deduct- ing ash and water.
	Carbon.	Hydrogen.	Oxygen and Nitrogen.	
Bwlf.....	91.08	3.83	5.09	15804
Powell.....	92.49	4.04	3.47	16108

CONVECTION APPLIED TO THE DETECTION OF HEAT.—II.

BY LEROY C. COOLEY, PH. D.

Since the publication of a former paper on this subject in this Journal (Vol lxvi, p. 343), various experiments have brought about a change in the form of the convection thermoscope, by which its sensibility is increased, and its adaptation to a wider range of experiments secured. But, before entering upon any description, I hasten to call attention to the following extract from a lecture by the Earl of Rosse, at the Royal Institution, on May, 1873, from which it will be seen that something in the same direction has been done by the eminent physicist Joule. The original paper is not within my reach, nor have I seen any full report of the Earl's lecture. This extract was copied from a printed extra copy of the lecture, and kindly sent to me, since the appearance of my former paper, by Dr. Alfred M. Mayer, who received it from the hand of the Earl in London :

"Prof. Joule, in 1863, by means of a cylindrical glass vessel, divided in a vertical direction by a blackened pasteboard diaphragm, which extended to within one inch of the cover and of the bottom of the vessel, and in the upper of which spaces was delicately suspended a magnetized sewing needle furnished with a glass index, was able to detect the heat from a pint of water heated to 30° C., placed in a pan at nine feet distance; also that of a moonbeam admitted through an opening in a shutter as it passed across the apparatus."

The instrument which I have devised, while ignorant of Joule's experiments, is so different from that indicated by the above description, that I still feel justified in calling attention to it, and the more fully so since the simplicity of its construction, its sensibility and its cheapness combine to commend it to the favorable notice of those who have need of a sensitive thermoscope, without being able to command the expensive thermo-multiplier of Melloni.

In the original form of the instrument, a very light glass needle,

suspended in a horizontal position by a fine silk fibre, was enclosed in a cylindrical glass case. A very gentle air-current, such as the presence of a warm body occasions, acting upon the end of the needle thus arranged, will waft it along, and a horizontal graduated circle below may show the extent of the motion.

The torsion of the suspending fibre and the inertia of the needle are the two resistances to be overcome by the force of the air-currents before the needle can move. Evidently, with a needle of given weight, these resistances will be overcome most readily when the fibre is longest and finest, and when the needle is also of the greatest practicable length. Constructing the instrument accordingly, it was found that the needle refused to maintain any one position over the scale. Subject to the influence of external sources of heat, it would rest nowhere long. Even the presence of the experimenter was a disturbing element. This difficulty could be overcome only by changing the character of the chamber so that the interior may be protected from any sudden local change of temperature. A long and light needle, a long and delicate fibre for its suspension, and a chamber whose walls will protect its interior from the influences of surrounding sources of heat—these are the requisites in the construction.

Twelve inches was chosen to be the length of the needle. A glass tube, about one-fourth of an inch in diameter, was drawn out, while hot, until so small that the required length was little more than able to sustain its own weight when suspended. A disk of paper, three-sixteenths of an inch in diameter, was laid upon one end of this slender tube, and cemented there by a minute drop of wax.

This needle was suspended horizontally, with the plane of the disk vertical, by means of a single fibre of silk, about eighteen inches in length, extending upward in a long glass tube projecting from the top of the chamber for its protection.

The chamber is a double-walled box, measuring eighteen inches in length by four in width and six in height. Its inner walls and bottom are of glass; its outer walls and top are of wood, a glass window being inserted in each end. The two walls are separated by an air-space of about half an inch. And, finally, the whole exterior, except the windows at the end, is covered with gilt paper, that it may be a good reflector.

An opening in the top of the chamber above the needle-disk allows the introduction of objects into the neighborhood of the disk when their temperature is to be tested, but to adapt the instrument to ex-

periments with radiant heat another arrangement is added. Opposite the needle-disk an opening through both walls of one side of the chamber permits a conical reflector to project slightly into the interior. The small inner end of this reflector is about a half inch in diameter, and is closed air-tight by a disk of the thin glass used for microscopic purposes. This glass may be blackened if necessary. When not in use, the outer end of the reflector may be covered. The heat radiated from an object in front of the cone will be thrown upon the thin glass at the inner end. The gentle warmth of the glass will occasion air-currents within the chamber, by which the disk will be wafted toward the cone. A scale engraved upon a vertical glass, standing in front of the disk, enables the motions of the needles to be seen and compared.

The description of two or three experiments from among the many made with this apparatus will suffice to show the delicacy of its indications.

A rectangular tin vessel, filled with water at a temperature of 95° F., and exposing a radiating surface of eight by ten inches area, was placed at a distance of twenty feet in front of the cone. The temperature of the interior of the thermoscope was 54° F. At the end of three minutes the needle was perceptibly in motion.

The needle having been stationary for twenty-seven minutes preceding, I seated myself at a distance of twenty feet in front of the cone, with my face toward it. The temperature of the interior of the instrument was 57° F. Five minutes afterward, on returning to the apparatus, the needle was found to have moved toward the cone.

The out-door temperature, one day, being 38° F., and that of the thermoscope within being 68° F., the cone was pointed toward a window twenty-one feet away. When the needle had been at rest for ten minutes the cone was uncovered. In eight minutes afterward a perceptible motion had occurred; the disk had moved *away from the cone*, indicating cold.

In attempting to use this instrument for lecture purposes, the slowness with which the needle returned to the zero of its scale after experiment was a source of annoyance, and its prompt return could be secured only at the expense of some degree of its sensibility. Among those tried were the following well-known methods of suspension:

A fine thread of spun glass, two feet long, was used in place of the silk fibre. The torsion of this thread will bring the needle to its zero with considerable promptness. Its sensibility is very much impaired,

but not to such an extent as to prevent its response to very delicate changes in the temperature of bodies which may be thrust into the chamber. Such experiments as those described in the former paper may be made very satisfactorily with this instrument; but for experiments with radiant heat the bi-flar mode of suspension is better. Two single silk fibres, parallel and near together, sustain the needle, and allow it to remain away from its zero only while under the influence of the heat currents.

The directive force of a magnet (Joule's method) was also tried. The needle being suspended by a single fibre of silk, a delicate magnet, made by taking a quarter inch in length from the fine end of a small sewing needle, and slightly magnetizing it, was placed under the centre. This instrument was less sensitive than either of the others. Moreover, when iron was used in any way as the source of heat, the magnetic influence could sometimes be detected, and thus tended to obscure the indications of the thermoscope.

A beam of light, from which the heat has been filtered, may be thrown through the thermoscope lengthwise of the needle, and, by means of a lens, may be made to form the image of the disk upon a screen. By this means the motion of the needle-disk toward or from the object, according as the temperature is higher or lower than that of the instrument, has been seen, at once and distinctly, by a large number of persons. Thus, the heat evolved by the fall of a hammer through a few inches upon a copper wire lying upon an anvil, may show itself to a large audience when the wire is thrust into the chamber. The heat, by the chemical action of a single drop of oil of vitriol with only its proper quantity of water, will show itself by the motion upon the screen, when a wire, after remaining a moment in the mixture, is thrust into the neighborhood of the disk. The cooling of the wire by evaporation, when moistened with ether, is shown by the disk-image flying away from it on the screen. Let a small copper wire pass through a cork, closing the opening in the top of the chamber down to a level with the disk, while its upper end, being bent into a horizontal direction, projects over the edge of the instrument. Apply the heat of a spirit lamp to the outer end of the wire. In less than a minute the disk will be seen moving toward the inner end of the wire, showing the transmission of heat by conduction.

THE METALLURGY OF THE FUTURE.

An Address delivered before the Society of Civil Engineers of France on the 9th of January, 1874, by their President, M. JORDAN.

[Translated from the "*Revue Industrielle*."]

(Continued from page 344.)

The science of molecular mechanics is yet in its infancy ; and for this very reason it presents a rich field for investigation and experiment. We are already acquainted with iron, for example, in very many physical conditions. We have learned within a few years how to obtain it melted like steel and cast-iron. But how numerous are the things which yet remain for us to learn, in order to understand the properties of even these various states of iron ; in order to explain the peculiarities which they present when viewed from the standpoint of construction ; in order to establish the relation which should subsist between these different molecular states and the resistance of the metal under various strains ; in order to have as definite a theory for working iron cold as for working it hot. This knowledge, which may be called the physics and the molecular mechanics of iron, is still very rudimentary. We have in our own ranks—and we may be proud of him—a learned engineer who was among the first to devote himself to the ascertaining of this knowledge ; his researches upon the flowing of solids and upon the forging of metals, are destined to bear him rich fruit, especially in connection with the parallel series of experiments upon the resistances and the deformations of metals, which he has published with them. Will he permit me to express a regret that he has not decided to communicate to the engineering profession, through the agency of our own organization perhaps, the valuable data already in his possession, which would form so exceedingly valuable a basis for future investigations of the same sort ?

Availing myself of this opportunity, I will attempt to lay before you a sketch of what I foresee in these molecular studies, at present unfortunately too much neglected. I will enter upon the subject through a phenomenon well known to every one. It is a matter of common knowledge that iron is capable of being welded ; that if two pieces of iron be heated to a temperature, called for this very reason a welding heat, and then be pressed together, either by hammering or by energetic pressure, the two pieces will be firmly united ; *i. e.*, welded together. Why is this ? The only explanation which we can

find in the best works on chemistry or metallurgy is the following : "At a white heat, iron acquires the property of being welded, a property which it shares with the metal platinum only." But obviously there is no evidence here of any mysterious and special property of iron called weldability ; there is only the effect of a very general cause, the manifestation of a molecular property elsewhere abundantly active in nature.

Take two pieces of ice, and a temperature just below zero, press them even very gently together ; they become at once welded to each other. This is the phenomenon, first observed by Faraday and subsequently investigated in so fascinating a way by Thomson and Tyn-dall, which has received the name "regelation." Thomson explains it in the following manner : For all bodies, like water, which have the property of diminishing in volume as they liquefy, pressure, which tends to bring the molecules closer together, lowers the temperature of fusion. Consequently, when two pieces of ice are rubbed against each other, fusion takes place between the surfaces of contact, at a temperature below zero. Of course, as soon as the pressure ceases, solidification is again produced and the pieces are welded together.

It seems to me that the welding of iron is a phenomenon exactly similar to regelation. The two pieces of iron are brought to a white heat, that is to say, more or less near to the fusing point. The repeated blows of the hammer, or the pressure of the rolls, lowers the point of fusion and causes a superficial liquefaction of the parts in contact, and thus welds the masses together ; and this, because, like water, iron dilates in passing from the liquid to the solid state. Many other metals are similarly endowed ; they all therefore may be welded like iron, if other conditions do not come in to oppose the manifestation of this property. Platinum welds easily at a white heat because its non-oxidizable surface, like that of ice, takes on a superficial fusion. To weld iron successfully it is necessary that its surface should be clean, that is, free from oxide. Iron containing phosphorus welds more easily than pure iron, because its point of fusion is lower. Steel, which is more fusible still, welds at a lower temperature than iron, but the process is a more delicate one. Silver, too, like iron and platinum, has the property of expanding when it solidifies ; but as it melts at a cherry red heat, it is easier to form it by casting than by welding. Bismuth and zinc are also included in the same class ; but they are so very brittle near their fusing points that no one would think of attempting to weld them either by hammering or pressure.

Iron, in welding, therefore, only follows the example of water. The careful comparative study of these two bodies, even though at first sight apparently so dissimilar, cannot fail to furnish, for this reason, results of great interest to the metallurgist. I have lately read an excellent book by Mr. Tyndall, upon glaciers and the transformations of water, and I have been repeatedly struck with the great number of analogies presented by these two bodies. Indeed, I might almost say similitude, were not the fusing points of the two distant from each other more than fifteen hundred degrees centigrade.

When snow is at a temperature not too far below zero, children amuse themselves by making balls of this substance and increasing their size by rolling them upon the white layer beneath; the simple weight of the primitive ball being sufficient to cause the agglomeration of the successive layers. If a snowball be compressed in the hands a hard mass is obtained, which is at first white and opaque; if the pressure be increased a translucent mass results, and if it be very considerable, a piece of transparent ice is produced, care, of course, being taken to expel the traces of air entangled mechanically between the snow crystals.

Place fragments of ice, coarsely broken, in a mould furnished with a cover and compress them energetically, either by the blows of a hammer or by means of a press, and you will obtain, if the temperature of the mass be near 0° , a compact block which takes the exact form of the mould. Having moulds for roughing the block out and others for finishing it, you may stamp the ice so as finally to form an object of almost any desired form. In one of his celebrated lectures on heat, Mr. Tyndall made in this way a cable-link in the form of the figure eight. Pounded ice regelates better than snow, and therefore permits better the repetition of this last curious experiment. But even a snowball well compressed may be converted into the form of an elongated solid; and then, operating with care and slowly, one may, either by pressure or by a succession of slight blows, form it gradually into an ice-block of any desired form.

Now in what does all this differ from the work performed by the puddler when he forms his ball in the furnace by rolling together the crystals of iron which have come to nature there in the midst of the slag? when in shingling, the expulsion of the liquid scoria from between the crystals of iron is effected, either by pressure or by a blow; either under the hammer or within the squeezers? A piece of iron forged at a bright red heat seems to act like a viscous body; it

becomes extended in various directions, and in fact acts like the ice of a glacier, which flows along its bed, conforming itself to all its sinuosities. But the ice of a glacier is not viscous; it has been shown that this appearance is due to the continual formation of innumerable cracks, the surfaces being immediately united again by regelation, under the pressure of the superincumbent masses.

Even if iron can be forged at a red heat, we know that at this temperature it will not support severe traction. Iron wire, for example, cannot be passed through a draw plate at a high temperature, its resistance to traction being then too feeble. So it is with ice; if it can support a pressure, it cannot stand a tensional strain, but breaks without sensibly elongating.

Physicists, like Tyndall and Helmholtz, distinguish two kinds of ice; lake ice, which is formed by a regular crystallization on the surface of still water; and glacier ice, or compression ice, produced either from snow crystals or ice fragments, united into a single block by the effect of regelation. These two kinds of ice act very differently under the influence of an energetic compression. The former, or the crystalline ice, breaks throughout its mass into a great number of fragments; the latter, the amorphous or granular ice, changes its form and moulds itself anew, by a series of minute crackings scarcely to be perceived. So attempt to forge, without care, an ingot of iron or of steel, and you will cause it to crumble, because it is crystalline; but if you submit this ingot first to the operation of sweating, that is to say, if you heat it to the welding temperature and then, by an energetic pressure, you effect by regelation the welding together of the various crystals of the metal, you will then have a mass which can be forged without difficulty. Even the fragments of such a mass can be welded, although pieces of the primitive ingot are not weldable directly.

Iron made in the puddling furnace is crystalline. It becomes amorphous in the process of shingling and rolling. Steel cast at a temperature near its point of fusion and slowly cooled is also crystalline in the same way and for the same reason, as lake ice. I do not suppose it is necessary for me to say here that water and steel do not crystallize in the same system, nor to recall the fact that carbon and iron are isomorphous.

Again, both iron and cast steel, even after forging, by which all the cleavages have been welded together and the crystalline structure entirely destroyed, may crystallize anew under very many conditions.

I have recently seen a section of a steel cannon which was forgotten in the reheating furnace. When it was discovered and removed it was only a friable agglomeration of small, but well characterized, crystals. So no doubt a piece of compressed ice, maintained for a long time in a confined atmosphere—so as to prevent evaporation—and passing constantly to and fro in temperature, from 0° to -10° , would become crystalline and cleavable. I do not know if the experiment has ever been made; but it would certainly be worth the trouble.

Let me, just here, ask you to note how closely the point which Helmholtz maintained against Tyndall, relative to the innumerable crackings produced in ice by pressure, which permits the moulding of granular compressed ice into any shape, and hence allows it to flow though an opening, like a vein of liquid or like a wire, under the influence of hydraulic pressure, as Helmholtz in a recent lecture has experimentally shown; how closely the point which he makes, that the flowing of solid ice is simply the flowing of an infinite number of minute polyhedrons, resembles the theory which has been quite lately advanced by M. Tresca, concerning the laws of the flowing of solid bodies generally.

Thus far I have said nothing of fibrous iron, because the fibrous state of iron is not a normal and regular one. All crystalline iron, if the crystals are not too hard, breaks with a fibrous structure, if time be given, in the breaking, for these crystals to be drawn out into fibres. Iron which is fibrous is only iron in which the primitive crystals, surrounded by very thin films of slag—and thus separated from each other—have not been welded together during the rolling, but have been elongated into wires. A bar of such iron resembles a bundle of wires in its resistance to traction, but it breaks with a granular fracture when exposed to a transverse blow, suddenly applied.

In considering these two states of iron, the crystalline and the amorphous, we are unavoidably brought face to face with the question, what takes place when the metal passes from one of these states into the other? The experiments of MM. Favre and Silbermann, and of M. Ditte, have shown that bodies in crystallizing disengage heat; and, on the contrary, that they absorb heat in passing from the crystalline into the amorphous condition. This latter condition seems, therefore, to be an intermediate one between the crystalline state, which is a true solid form, and the state of a liquid. The amorphous state is consequently a dynamic state, as I have seen it somewhere defined; a state

of more or less unstable equilibrium. Has the crystalline iron which issues from the puddling furnace, and which we transform into amorphous iron by shingling and welding, absorbed any heat? Has it rendered latent any portion of the heat yielded by the fire or developed under the hammer? Are the specific heats of crystalline and of forged iron, at the same temperature, the same? Both these questions, interesting as they are to the theory of iron making, are yet without an answer.

Moreover, may not the heat which has thus been absorbed, being disengaged again under conditions at present but little known, become an active agent in returning the iron to its original crystalline condition, thus explaining those changes of structure hitherto attributed vaguely to great cold, to continued vibration, etc.? I have seen a bar of good charcoal iron from Franche-Comté, left accidentally for some weeks in the welding furnace, and having hence been subjected to intense heatings followed by extremely slow coolings; it had taken on a structure completely and largely crystalline, and yet had lost none of its original softness. Large forgings, such as armor plates, which have to be returned many times to the reheating furnace, and which, after each heating, cool very slowly under the repeated blows of the hammer, exhibit a strong tendency to crystallize in those central portions which are not reached by the blow. In fact these plates do often crystallize at the centre. In order to remedy this condition of things, which constitutes a serious defect, since fracture takes place readily through these cleavages, it is necessary after the plate is entirely finished, not to allow it to cool to the centre, but to place it again in the fire until the exterior has become red hot. It is then plunged into water, which for small articles must be hot, but is cold for large ones like armor plates. In this way the iron recovers its former strength. Without this precaution a plating of good soft-iron would break under the blow of a projectile, with large crystalline facets, instead of resisting its impact. This hardening of masses of iron, which is a device now extensively practiced, does not succeed unless the iron be very soft. It is necessary too that the iron should not be hard from the presence in it either of carbon or of phosphorus. The rapid cooling of amorphous iron of a good quality appears to prevent the formation of crystals; very slow cooling, on the other hand, seems to have the contrary effect.

One step more. If in place of considering water and iron in the solid state we compare them in the liquid condition, we find here,

too, many curious facts well worthy of investigation. We know, for instance, that water may be cooled, even to -12° without ceasing to retain its liquid form, if it be left in absolute quiet, and protected from the air. We also know that when in this condition vibrations of any sort, such as would be caused by drawing a bow across the edge of the vessel which contains it, or the contact of a small bit of ice, suffices to determine the solidification at once. The point at which which ice melts is therefore fixed; the point at which water solidifies is not; water may solidify at a number of temperatures. It passes into the solid state, however, when it does congeal, as much more rapidly as the temperature is inferior to the fusing point, disengaging therefore, in the process, an amount of heat proportionally greater. When the solidification takes place thus rapidly the molecules have not time to take their positions of stable equilibrium, and crystallization cannot operate. Now have these phenomena of aqueous surfusion anything analogous in the case of molten iron? Would not this be the proper place for some curious comparisons with what we observe in the casting of iron and steel? The temperature at which steel solidifies has certainly considerable influence upon its grain. We recall here, too, the practice commonly employed with certain steels, of closing hermetically at once the ingot moulds, as soon as they have received the metal, and then abandoning them to rest until the solidification is complete. We know, too, that when the steel solidifies in a mould which is in motion, the structure is more massive and less crystalline than when the mould is at rest.

I have now reached the end of my long address. You will pardon me, I trust, for having made it rather a lecture than an opening discourse upon principles and methods. Permit me, in closing, to reiterate the assertion that there are many points in the molecular states of iron which will richly repay the attention, not only of men of science, accustomed to the most delicate researches, but also of those practical men who, as engineers, are engaged in the manufacture or the utilization of this metal. I shall deem myself most fortunate if my feeble voice shall induce even a single physicist to undertake the investigation of some of the problems which suggest themselves in practice; problems, our ignorance of the solution of which prevents progress in all those directions, at least, where it is absolutely necessary to have, as a guiding thread, a sound theory built upon experience.

ON THE MECHANICAL PROPERTIES OF MATERIALS OF CONSTRUCTION,

And on Various Previously Unobserved Phenomena, Noticed during Experimental Researches with a New Testing Machine, with Autographic Registry.

BY PROF. R. H. THURSTON.

SECTION II.

SOLUTION OF PROBLEMS AND EXPERIMENTAL RESEARCHES.

14. **INTRODUCTORY.**—The preceding section has been devoted to a description of the peculiar form of testing machine employed by the writer during these researches, to an account of the general method of obtaining from any material an autographic record of its mechanical properties, and to the interpretation of strain diagrams thus obtained from the useful metals, and other materials of construction.

The part here presented contains an account of some of the more interesting and fruitful of the special investigations conducted with the apparatus, and embodies a description of certain remarkable and hitherto unobserved phenomena accompanying the distortion of metals, the discovery of which must affect the theory of the effect of stress in producing strain, and consequently must somewhat modify engineering practice.

15. **GENERAL DEDUCTIONS.**—From what has already been shown, we may deduce the following *résumé* of methods of determining the several more important properties of materials by an inspection of their strain diagrams.

(1). *To Determine the Homogeneousness of the Material.*—Examine the form of the initial portion of the diagram between the starting point and the sudden change of direction which has been shown to indicate the elastic limit. Notice, also, its inclination from the vertical, and compare with it the inclination of the “elasticity line.”

A perfectly straight line beneath the elastic limit, perfectly parallel with the “elasticity line,” shows the material to be *homogeneous as to strain*; i. e., to be free from internal strains, such as are produced by irregular and rapid cooling, or by working too cold. Any variation from this line indicates the existence and measures the amount of strain. A line considerably curved, as in No. 6, Plate I, exhibits the existence of such strain.

Next, examine the form of the curve immediately after passing the elastic limit.

A line rising from the elastic limit regularly and smoothly, approximately parabolic in form, and concave toward the base line, as in No. 22, indicates *homogeneousness in structure*, and the absence of such imperfections as are produced in wrought iron by cinder, or in cast metals, which have been worked from ingots, by porosity of the ingot.

A line turning the corner sharply, when passing the elastic limit, and then running nearly or quite horizontal, as in other irons and in the low steel of Plates II and III, or actually becoming convex toward the base line, as with some of the woods in Plate I; and then, after a time, resuming upward movement by taking its proper parabolic path, indicates a decided want of this kind of homogeneity. The relative length of the depressed portion of the line, and the amount of depression, measures the relative defectiveness of materials compared in this respect. Finally, compare the diagrams produced by several specimens of the same kind of material, or from the same mass.

Homogeneousness in general character and *homogeneousness in composition* are proven by the precise similarity of these diagrams, while a greater or less variation of the curves compared, indicates a greater or less difference in the specimens of which they are the autographs.

Materials should usually exhibit great homogeneousness in all these three ways, to be perfectly reliable. *Perfect* homogeneousness is not to be expected in either respect.

(2). *To Determine the Elastic Resistance of the Specimen.*—Measure the height of the curve at the elastic limit, using the scale of torsion, or for tension, which is given for each machine and for each standard size of test piece, as shown in the accompanying plates.

(3). *To Determine the Resistance Offered to any Given Amount of Extension, or that Producing a Given Set.*—Measure the ordinate of the curve at the point whose abscissa, or distance from the origin, measures the assumed degree of set.

(4). *To Determine the Ultimate Resistance of the Material.*—Measure, in a similar manner, the maximum ordinate of the curve.

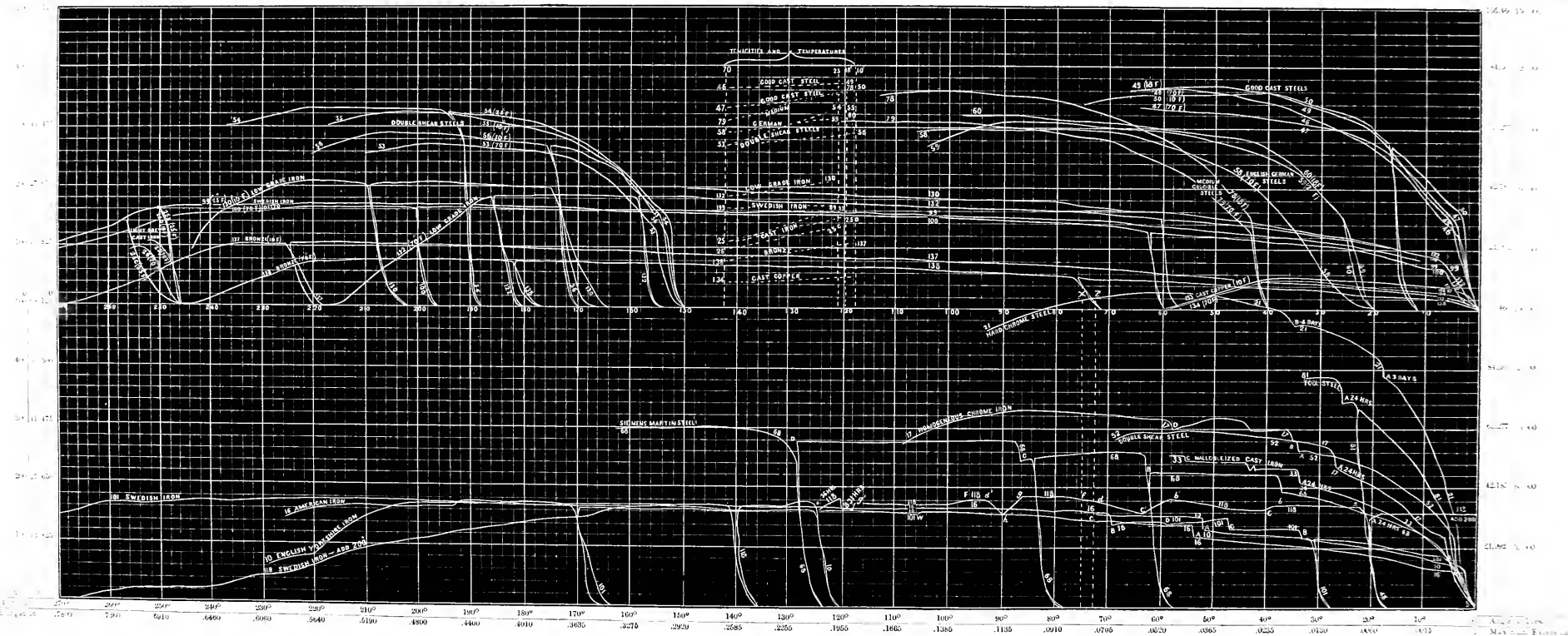
(5). *To Determine the Resilience of the Piece Within the Elastic Limit; i. e.,* the work required to produce an evident and permanent set, approximately proportional, in amount, to the degree of change of form of the specimen. This quantity measures the power of the material to resist blows, and its determination is evidently quite as important as that of resistance to static stress, which latter forms one of the factors of the former.

AUTOGRAPHIC STRAIN-DIAGRAMS OF METALS, ILLUSTRATING THE EFFECTS OF TIME AND OF TEMPERATURE UPON RUPTURE,

PRODUCED BY THE
TESTING MACHINE OF PROFESSOR R. H. THURSTON.

JOHN M. MONTGOMERY
J. H. K. MONTGOMERY
J. H. K. MONTGOMERY

APPROPRIATE
THURSTON
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Measure the area comprised between the ordinate of the curve at the elastic limit and the initial part of the curve. This quantity is proportional to the required value. Or, multiply the elastic resistance of the material by the extension within the elastic limit. As an approximate result, two-thirds this product is the quantity required, in inch-pounds or foot-pounds, according as measures of extension are taken in inches or feet.

(6). *To Determine the Resilience of the Material Within any Assumed Limit of Extension, i. e.*, the magnitude of blow required to produce a given set.

Measure the area of the curve up to the assumed limit; as, for example, the area, in Plate III, under No. 21, Z , 21, 21, Y , x ; where the assumed set is the extension from Z to x . Two-thirds the product of the resistance, measured by the altitude Yx , and the extension bx , gives, as before, an approximate value for ordinary purposes.

(7). *To Determine the Total Resilience*, or shock-resisting power, of the material. Measure the total area of the diagram. For ductile materials, an approximate value is obtained by taking two-thirds the product of the maximum tenacity by the maximum extension. For hard and very brittle materials, one-half the same product gives very accurately its values. For intermediate qualities, the true value is more nearly two-thirds this product, also. Swedish wrought-iron, white cast-iron, and hardened steel illustrate the first and the second classes; ordinary tool steels are examples of the third class, as is also iron like No. 22.

(8). *To Determine the Effect of a Load Given in Pounds per Square Inch of Stress*.—Find a point in the curve having an ordinate which measures the given stress. The abscissa of that point measures the extension under that load. In other words, a point being found in the curve, the height of which above the base line is equal to the load per square inch, its distance from the origin measures the extension of the material as produced by that stress.

(9). *To Determine the Effect of a Blow, or a Shock, whose Measure is given in inch-pounds of Energy, i. e.*, of which the work, which it is capable of doing, is known.

Find a point on the curve whose ordinate cuts off an area, between itself and the origin, representing the given amount of work. Or, find such a point that two-thirds the product of the stress measured

by its ordinate, and the extension corresponding to its abscissa, is equal to the number of inch-pounds given. The position of this point shows the maximum strain and the maximum extension of the material under the assumed conditions.

Drawing a line through this point parallel to the nearest "elasticity line," the distance of the point at which it intersects the base line from the origin indicates the resulting set.

(10). *To Determine the Effect of a Blow upon the Material when already Strained by a Dead Load.*—Determine first the extension produced by the application of the static stress, as in (8), and then find that point on the curve between the ordinate of which and the ordinate of the point indicating the strain just found as due the dead load, an area is intercepted which measures the work done by, or the energy of, the shock which has been assumed or calculated.

16. EXAMPLES.—Illustrations of the first seven of the above described processes are given either in the preceding portions of this paper, or will be noticed hereafter during the progress of special searches. Those succeeding may be illustrated thus:

(1). Given, a load of 30,000 pounds per square inch. Determine its effect upon good qualities of cast and wrought iron, low steels, tool steel and the weaker metals.

Referring to plate II for examples, we find that neither cast copper, lead, tin, nor zinc would sustain such strain. All would be broken.

Good iron, Nos. 1 and 6, would be strained beyond their limit of elasticity and would take a set after an extension of about 1 and $1\frac{1}{2}$ per cent. respectively. The exceptional iron, No. 22, would be strained to a point which is so nearly its elastic limit that it would remain practically uninjured.

The low steels, Nos. 69, 67, 76, would bear the stress with a similar degree of safety, very nearly. The first would have a considerable margin of safety within its elastic limit; 67 would be nearly, and 76 would be quite, strained to the elastic limit, while 98 would take a set of about one-fifth of one per cent.

If the strain were torsional, the weaker metals would be twisted off by a force corresponding to that here assumed, the good irons would take a set of about 25° , the best iron and the three stronger steels would take no appreciable set, and the softest of the latter would set at about 10° . In these cases, the specimens are supposed of standard

size. For other sizes the forces producing similar effects would vary as the cube of the diameters.

(2.) Given, the magnitude of a shock, or blow, *e. g.*, as equal to that due a weight of one ton,—2000 pounds,—falling one foot, the rod taking the strain being of one square inch area of section, and one foot long. Determine the effect for each of the above-named materials.

The effect of this blow is equivalent to an expenditure of energy amounting to $2000 \times 12 = 24000$ inch-pounds.

The weaker materials, not possessing an ultimate resilience of this amount, would be broken.

Forged copper would be strained, and would take a set after very nearly 12.5 per ct. of extension, since $0.125 \times 12 \times \frac{24000 \times 2}{3} = 24000$, the work done by the blow being equilibrated by the product of two-thirds the resistance, noted at 110° , Plate II,— $\frac{24,000 \times 2}{3}$,—into the extension $0.12\frac{1}{2} \times 12$ inches. Perfect accuracy of figures may be insured by perfectly accurate measurements.

The specimen of iron No. 1 would be given an extension and set of very nearly 0.068, since the resistances under this amount of stretch would be approximately 45,000 pounds per square inch, and the work during extension would be $0.068 \times 12 \times \frac{45,000 \times 2}{3} = 24,000$ inch-pounds.

The iron of special grade No. 22 would be elongated $0.058 = 0.69$ inch,—as $0.069 \times 12 \times \frac{52,000 \times 2}{3} = 24,000$ nearly.

The same blow would produce on the rod, if made of such steel as No. 69, an extension of $0.0384 \times 12 = 0.461$ inch, estimated thus,— $x = 24,000 \div \frac{2}{3} \cdot 78,000 = 0.461$, it being found, by “trial and error,” that the extension 0.0384 develops a maximum resistance of 78,500 pounds per square inch.

It is evident that where extreme accuracy is required the curves should be transferred to a new scale, in which the abscissas should be a scale of elongation instead of angular distortion, and the area should be carefully measured.* For the latter work an Amsler “Planimeter”† is useful.

* See London “Engineer,” Nov. 8th, 1872.

† It is evident that diagrams accurately representing tests made with the common testing machine afford similar facilities for solving these problems.

(3.) Given, a bolt of dimensions as last assumed, strained with the effect of a load of 30,000 pounds, as in example (1). Determine the effect of a blow of 24,000 inch-pounds energy, occurring while the bar is sustaining the static load.

The effect of the dead load, as already calculated, is to produce a strain upon the low steels, and upon iron like No. 22, which would keep them extended only a very minute fraction of their original length, this extension being, even with the latter material, but 0.05 of one per cent.

The effect of the blow would be, practically, the same as has just been estimated for the unloaded bar.

Nos. 1 and 6 would be, as already shown, extended one and one and a half per cent., respectively, by the simple load. The added effect of the blow would be to produce an additional extension and set of 0.0533 and 0.0555 respectively, since the mean resistance, during this extension, is $\frac{45,000+30,000}{2}$ and $\frac{42,000+30,000}{2}$, respectively, and the extension must be, $24,000 \div \frac{45,000+30,000}{2} \div 12 = 0.0533$, and $24,000 \div \frac{42,000+30,000}{2} \div 12 = 0.0555$.

The bar is stretched, in the first case, 0.64 inch; in the second, 0.666 inch, by the blow, if made of such iron as that of specimens 1 and 6.

It should be remarked here, that although the diagrams obtained from the various materials tested give data from which to estimate their relative value in resisting shock, the absolute results of calculation, with no modification for varying rapidity of action, will be but approximate.

This is a consequence of the facts that the inertia of the body struck will affect the result, and that the actual resistance varies with the velocity of rupture. A rod which will sustain safely the blow of a heavy body, would yield readily under a blow of similar energy struck by a light weight moving with proportionally increased velocity. The mathematical investigation of this effect, which has not hitherto been noticed, remains to be given. It is only necessary to state here that a rod of uniform section, and homogeneous in structure, will be uniformly extended by a force slowly applied. A blow received at one end will extend it most at the portion nearest that end, and the more rapid the blow the more is its effect concentrated. It is possi-

ble to produce actual fracture at one end by a very rapid blow, and for rupture to become complete before the shock is felt at the opposite end. This action is seen daily in every workshop where pieces are broken from heavy masses by the blow of a hammer.

The effect of a blow depends, therefore, not only on the magnitude of that product of mass into height due its velocity which we call *vis viva*, but also upon the magnitude of the factors. It further follows that, of two materials having equal tenacity and equal ductility, that having the greatest density will be most liable to fracture by impact.* This information is confirmed by experience.

In general a rod should be somewhat larger at the end receiving the shock, and this enlargement should be greater as the blow is more rapid. Conversely, blows of equal energy are most injurious when given by bodies of light weight moving at high speed. This difference is exaggerated by any cause which increases the density of the material. The variation of resistance with rapidity of rupture will be considered more at length hereafter.

It is readily seen that we have here an explanation of the fact, that fracture produced by a quick blow is granular in character, while a steady pull brings out the "fibrous" texture of iron. In the former case the action is concentrated upon a cross-section close to the point at which the blow is received; in the latter instance inertia acts less effectively in resisting the transmission of the rupturing force to other portions of the piece, and the drawing out process is permitted to take place.

17. PECULIAR PROBLEMS sometimes present themselves in practice which cannot be solved by any published methods—why, it is difficult to say, but partly, it is probable, because of a deficiency of experimental data, and partly because known authorities have not been led by actual experience in engineering practice to perceive the importance of their applications.

Of these the following is an example:

To determine the effect of a succession of stresses, whether static or dynamic, each of which strains the material beyond the original or the acquired limit of elasticity. An illustration of this action is given by the repeated bending, stretching, or other form of distortion by external force, of any material producing at each application a new set. The same case is illustrated by the gradual elongation of a rod

* "Mechanics' Magazine," Dec., 1871, p. 492.

by repeated blows, the energy of each of which exceeds the elastic resilience of the material.

Determine the elastic resilience of the material existing previous to the application of each stress, by taking the area comprised between two lines drawn through that point on the curve of the material chosen, whose abscissa represents the existing extension, one of which lines is an ordinate and the other of which is parallel to the nearest "elasticity line." This area represents the elastic resilience of the piece; *i. e.*, a blow having an equivalent energy would leave the piece uninjured and without set. Deducting this amount from the energy of the given blow, the remainder of the work done by that blow is expended in producing set or extension, and may be determined as already described.

The effect of a simple force may be determined by deducting from the total distortion produced by each application of that force, the elastic range of the material.

It is thus readily ascertained, in either case, how much each application will add to the set, and how many applications will be required to produce rupture.

It is here assumed that distortion within the elastic limit leaves the piece uninjured, however often it may be repeated. This assumption seems correct, *a priori*, and is well sustained by the valuable researches of Wohler* and others.†

The effect of repeated bending or other form of strain, can thus be inferred from an examination of the strain diagram of the material, obtaining from a single experiment a determination hitherto only obtained by a long and tedious process of repeated distortion. Such investigations of the "fatigue" of metals are often of great importance.

18. THE EFFECT OF TIME ON METALS LEFT UNDER STRAIN.—The effect of stress is modified when metals are left under strain for considerable intervals of time. It had generally been supposed that this effect was to weaken the resistance whenever the material was left exposed to a strain exceeding the elastic limit.

This idea seems sustained by the experiment of M. Vicat, made at Paris about forty years ago.‡

* *Zeitschrift für Bauwesen*, 1860; *Festigkeitsversuche mit Eisen und Stahl*, Berlin; also *Lond. Engineering*, 1871.

† Fairbairn: *Civil Engineer and Architects' Journal*, Vols. XXIII, XXIV.

‡ *Annales de Chimie et de Physique*, 1834, Tome 54, p. 35.

M. Vicat states that four wires were extended, respectively, by $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$ and $\frac{3}{4}$ their ultimate resistance, and their elongations were observed and recorded at intervals of one year.

The relative extensions observed indicated a gradual lengthening of the three which were strained beyond the elastic limit, and that most strained finally broke, after sustaining $\frac{3}{4}$ its original ultimate breaking weight two years and nine months, the point of rupture being finally determined by the action of corrosion which had not been entirely prevented.

The several extensions were as follows :

No. 1, sustaining $\frac{1}{4}$, 33 months,	. . . . .	0.000 per cent.
No. 2, " $\frac{1}{3}$, " "		0.275 "
No. 3, " $\frac{1}{2}$, " "		0.409 "
No. 4, " $\frac{3}{4}$, " "		0.613 "

The rate of extension was nearly proportional to the times, and the total extension to the forces. M. Vicat concludes that metal thus overstrained will ultimately break, and his paper has caused much uneasiness among members of the profession, as indicating a possibility of the ultimate failure of structures having originally an ample factor of safety.

The elegant and valuable researches, also, of H. Tresca, on the flow of solids,* and the illustrations of this action almost daily noticed by every engineer, seem to lend conformation to the supposition of Vicat.

The experimental researches of Prof. Joseph Henry, on the viscosity of materials, and which proved the possibility of the coexistence of strong cohesive forces with great fluidity,† long ago proved, also, the possibility of a behavior in solids, under the action of great force, analogous to that noted in more fluid substances.

On the other hand, the researches of the writer, as described in the first section of this paper, indicating, by the form of strain diagrams, that the progress of this flow was accompanied by increasing resistance, and the corroboratory evidence furnished by all carefully made experiments on tensile resistance, as those of King and Rodman, Kirkaldy and Styffe, made it appear extremely doubtful whether materials were really weakened by a continuance of any stress, not originally capable of producing incipient rupture.

* *Sur l'Ecoulement des corps solides*, Paris, 1869-72.

† *Proc. Am. Phil. Society*, 1844.

18. To determine this point, a series of experiments was made, the general result of which was first formally announced in a note to the American Society of Civil Engineers,† in which the first experiment, commenced during the session of the National Academy of Science at the Stevens Institute of Technology, was described, and in which the first deductions, since slightly modified by an extended investigation, were given. In Plate III, No. 16, is a *fac simile* of the strain diagram obtained at the first experiment.

A piece of iron, of a good quality of metal, but badly worked, as shown in the sketch already given in Section 1, was placed in the machine and strained considerably beyond its elastic limit. It was then left twenty-four hours under the strain thus produced at A, Plate III. At the end of this period, the pencil was found precisely as it was left, and not the slightest evidence of yielding was noted. The slight depression observed in many examples to be given, is produced by a slight compression of the wood used in blocking the machine at the beginning of the interval. No evidence of flow was therefore obtained.

Upon attempting to produce further change of form, however, the unexpected discovery was made that the test-piece had acquired an increased resisting power. The pencil, instead of following the general direction taken the day previous, rose, as seen in the diagram, until a resistance was indicated, *exceeding by nearly thirty per cent.* that shown before the specimen was left under strain. This resistance having been overcome, the piece yielded with a slightly decreasing resistance, and, after considerable additional distortion, was left at B twenty-four hours. The result of the second experiment is seen to be an increase of nearly fifteen per cent., and a third trial at C gave a small, but still perceptible, gain also.

This singular phenomenon appeared so remarkable and so important that experiments were continued upon various grades of iron, and upon other metals, the greatest care being taken to avoid any possible source of error. Several strain diagrams are given illustrating some of these experiments.

No. 10 represents that of a piece of good iron which is far more homogeneous and better worked than 16.

No. 68 is a piece of "Siemens-Martin steel" which was left under

† See *Trans. Am. Soc. C. E.*, Nov. 1873; *Journal Franklin Institute*, March, 1874.

strain, at *A*, twenty-four hours, and at *B* an equal length of time. In the latter case, the applied force was wholly removed, at the end of twenty-four hours, before an attempt was made to produce further change of form. On renewing the strain the resistance is seen to have acquired an increased intensity very nearly absolutely equal to that shown at *A*, and relatively greater, a fact which will be found to aid in the determination of the real character of the phenomenon. A third experiment, at *C*, shows a repetition of this action, and a fourth, similar to that at *B*, in all except time—for in the last experiment the time was but a fraction of an hour—gave a similar result. In each case it is noticeable that a slight fall from the maximum attained follows the yielding of the test-piece.

No. 33, malleable cast iron, No. 52, double shear steel, and No. 81, tool steel, all exhibit this same stiffening under prolonged strain.

No. 17, "homogeneous chrome iron," was subjected to experiment four times. At *A*, the effect is very marked, and the resistance to further change of shape continues to increase slowly until left at *B* for a second trial. The maximum attained at *B* is not sustained, as further distortion occurs, and, after a slight decrease, the specimen was again left, the pencil resting at *C*.

Next day, the increase of resistance was found less considerable than at the previous experiment, and the line, after passing a maximum a few degrees beyond, falls quite rapidly. Fearing that the metal was about to rupture completely, it was left once more at *D*, another day, after which time its behavior was similar to that on earlier trials. It fully regains the maximum power of resistance noted after the trial at *C*, and, before rupture, it even slightly exceeds it.

The hardest material experimented upon was the very hard chrome steel, No. 21. Left at *A* three days, the resistance at that degree of distortion was increased about eight per cent., and, again at *B*, four days under strain gave a rise of nearly four per cent., after which a considerable rise occurred, in the ordinary manner, before rupture took place.

An interesting experiment was made with the best Swedish iron, a metal of such wonderful purity and ductility that one specimen, of standard size, was twisted nearly 600° before completely breaking off.

No. 101, Plate III, is the strain diagram of the specimen tested for the purpose of determining the effect of continued stress. Here,

as seems frequently the case, a loss of ductility apparently accompanies the increase of resistance. and the total resilience appears to be comparatively slightly altered.

This specimen was strained until the limit of elasticity was just passed and was then left at *A* one day. The result, with even this slight distortion of but six degrees, producing an extension of a very minute amount, is similar to that before noticed, and the behavior here exhibited probably gives a clue to the causes of this peculiar action. After this trial several others were made, and the metal is seen to have behaved in a manner precisely similar to the other grades of iron.

20. Reviewing all of the large number of experiments made since the discovery of this effect of continued strain, carefully comparing the curves obtained with each other, and with the diagrams obtained in the ordinary way, and, finally, making a comparison of the conclusions drawn from this research, with the results of the experimental work of other investigators, the writer has been led to the following, as the most probable explanation of this singular molecular phenomenon.

These strain diagrams are the *loci* of the successive limits of elasticity of metal, at successive positions of set.

*The phenomenon here discovered is an elevation of the limit of elasticity by a continued strain. The cause is probably a gradual release of internal strain, occurring in a somewhat similar manner to that observed previously in cast iron in large masses, and, less frequently, and generally in a less marked degree, in wrought iron and other metals, which have been worked in large pieces, and in which such strain has been more or less reduced by a period of rest.**

This loss of strength in large masses of wrought iron is stated, by Mallet, to amount frequently to one-half.†

* Compare London "Iron," Stability of Iron Structures, Feb., 1874; Van Nostrand's Magazine, April, 1874.

† On the co-efficients of elasticity and rupture in wrought iron in relation to the volume of the mass, its metallurgic treatment and the axial direction of the constituent crystals. *Proc. Inst., C. E.*

(To be continued.)

SECOND CHEMICAL AND SANITARY REPORT UPON THE WATER SUPPLY OF THE CITIES OF NEWARK AND JERSEY CITY.

BY PROFESSOR HENRY WURTZ.

(Corrected and prepared for this Journal by the Author.)

(Continued from page 337.)

2. *The River at the Falls.*—The sample collected July 24, above the falls (No. 9), will do well to compare with the series collected on the previous day in the lower basin. In appearance it was beautifully limpid, this limpidity being due to the long, still, deep and shady two-mile reach just above the falls, which acts as a settling reservoir. I may here throw in the suggestion that the canal—were it to be taken by your Honorable Commission as an aqueduct, and the continual wash against the banks, from the boats, thus ended—would do a like work with this extended lagoon above the falls, and its water would quickly become equally limpid and translucent. On proceeding up-stream towards Little Falls—as soon as the lagoon was passed and the water began to ripple (which is somewhere about the Midland Railway Viaduct), it was seen to be opalescent, so that the bottom could scarce be discerned at one foot depth; the impurities from the factories and dwellings at and about Little Falls becoming perceptible to the eye, as well as to the smell and taste.

The analyses quoted in Table III furnish an idea of the changes impressed on the water by passing through the cities of Paterson, Passaic, etc. We may compare for this purpose the mean of the two low-tide samples, Nos. 2 and 4, as well as some of the figures of No. 2 directly.

It appears, therefore, that the Belleville water averages a grain more per gallon of total solids, and about a grain and a quarter more of mineral matter, derived from town sewage, than that above the falls, but that the silt precipitated by the sewage below the falls, or some other agency, makes away with 0.36 grain of the organic matter present. The nitrates are less at Belleville, through action of vegetation in the stream below the falls. The “albumenoids,” however, notwithstanding the constant absorption by weeds and fish, are more than doubled, and if we take the result in the low-tide water alone, at the Newark Works, nearly quadrupled. The chlorine also undergoes a marked increase, as it inevitably must from sewage contamination, from 0.252 to 0.332 in the low-tide Newark water.

TABLE III.

Number.	SAMPLES.	Total Solids.	Loss on incineration	Ash.	Nitric Acid.	Saltpetre equivalent	Ammonia from Animal matter.	"Albumenoid" matters.	Chlorine.	Common Salt equivalent.
1	Passaic River, at head of Falls.....	4.584	1.501	3.0-3	0.334	0.624	0.023	0.234	0.262	0.416
2 & 4	Mean of two Low-tide samples at Belleville.....	5.431	1.140	4.201	0.303	0.567	0.049	0.496	0.274	0.452
3	Low-tide sample at Newark Works.....	.....	.....	.....	0.233	0.433	0.087	0.875	0.332	0.547

TABLE IV.

Illustrating the successive changes of composition of Passaic Water, while flowing from the Falls at Paterson to and through Newark, and back again to Belleville with the rising tide—during the Summer season.

Number.	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
	SAMPLES.	Total solids.	Loss on incineration.	Ash.	Nitric Acid.	Saltpetre, equivalent to the Nitric Acid.	Combined Ammonia.	Urea, equivalent to the combined Ammonia.	Ammonia from Animal matter.	"Albumenoids."	Chlorine.	Common Salt equivalent to the Chlorine.
9	Water of Passaic Falls—July 24.....	4.584	1.501	3.083	0.334	0.624	.....	.....	0.023	0.234	0.262	0.416
2	Low tide at Newark Water Works—July 23.....	5.455	1.105	4.350	0.233	0.433	0.023	0.041	0.087	0.875	0.332	0.547
4	" " Jersey City Water Works—July 23.....	5.407	1.175	4.232	0.374	0.700	none	none	0.117	1.167	0.216	0.356
16	River in Newark—just before ebb—August 20.....	5.249	1.575	3.674	0.187	0.350	0.058	0.103	0.117	2.016	.....	.....
17	" " " just after flow began—August 20.....	6.833	1.468	4.375	0.037	0.070	0.029	0.052	0.292	0.292	0.288	0.476
3	High tide at Jersey City Water Works—July 25.....	6.178	0.772	5.406	0.374	0.700	none	none	0.029	none	0.433	0.713
1	" " Newark.....	5.995	0.747	5.248	0.278	0.520	0.012	0.021	none	none	.....	.....

Nevertheless, it must be frankly said that this analysis of the water of the falls at Paterson by no means justifies the high estimate that the people of that pleasant city appear to entertain of the purity of their water supply; but rather agrees with what might be expected of a stream, one of whose tributaries (the "main" Passaic) comes down from a thickly populated agricultural country, full of towns and villages; and runs, moreover, through a large swampy district, (the "Great Piece Meadows"), frequently inundated.

On the occasion of an excursion of Chief Engineer Bailey and myself, up to Beavertown, we inspected and examined the Passaic above Little Falls. To both Mr. Bailey and myself the water in the reach above Little Falls had an unpleasant taste, and the wind blowing over it wafted a disagreeable odor. The water was not very clear in this reach. This was July 24.

In order to follow out the successive changes of the composition of the stream in its course through the lower basin, from the falls through Paterson and Passaic, through Newark, and back with the rising tide through Newark again up to Belleville, I have constructed the following table (Table IV), which, however, it must be remembered, does not furnish a strict comparison, as the samples in the city of Newark were taken nearly a month later in the Summer than the others. This table, however, will repay attentive study.

A gradual increase appears in total solids and in dissolved mineral matter, in consequence of influx of sewage. The rising tide shows less of nearly every ingredient at the Newark works than at the Jersey City works below, doubtless in consequence of greater admixture with the down-flowing water of the stream itself. This does not hold as to chlorine, however, which is increased in proportion by this admixture with the water from above, conveying the excreta of the large population of men and animals on the banks.

The nitrates are very variable, in consequence, as already explained, of variable action of vegetation in different parts of the stream, combined with the constant development of these nitrates by oxidation. There is a large increase of dissolved animal matter from the falls to the Newark Works, which doubtless contributes to support the fish that densely populate the stream at and above Belleville, and which, therefore, dwindles down rapidly, until enormously reinforced at Newark, and then again dwindles down to nothing—partly consumed by the fish, but also by vegetation and oxidation—during the up-flow. The effect of oxidation is manifest, during this

up-flow, by examining the nitric acid (column 5), which shows a maximum in the up-tide at the Jersey City works, and then a rapid diminution again, through vegetative action. Examination also of column 3 illustrates the same surprising changes—the amount of volatile and combustible matter, notwithstanding the Paterson and other sewage, actually diminishing from the falls down to the Water-works, and the maximum of these ingredients—in the channel at Newark just before ebb, 1.575 grains—running down rapidly during the flow up to the Newark Water Works to only 0.647 grain. The rapidity of these variations is here most astonishingly exhibited, and I would throw out the suggestion (or rather, on my own part, the conviction) that we owe our health (such as we have) and probably our lives, during the Summer season at least, to the concurrent action of these three causes, animal and vegetable life, and oxidation. Should any one, and especially any two, of these fail us, the consequences may readily be conjectured. At some time, as may be confidently predicted both the plants and fish will fail us. The very excess of nourishment that we now provide for these living things may at any time lead to their sudden or rapid extinction, as, in fact, it already has at other points in the river.

3. *The Canal—The Long Level.*—On the same occasion referred to above, of the excursion with Mr. Bailey, the water of the canal was examined and tested at several points. It was found to be more or less turbid, from the constant wash of the banks. The taste of the water opposite Little Falls appeared to be of an earthy or clayey character, very slight, and probably due to the same cause as the turbidity. This taste I was unable to perceive at the point near Beavertown, where our sample was collected, which is, I should add, on the same level (the “seventeen-mile level”).

It will be observed that the results of the analysis of this sample compare much to its advantage with that of the Passaic Falls, there being a trifle more of mineral matter, however, which is no important objection. (See Table V.)

This, moreover, does not tell the whole story, for the canal, after taking in below, upon this same level, the water of the Pompton feeder, which is much purer still, must change its composition very considerably for the better.

In the next paragraph this will be again referred to.

TABLE V.

SAMPLES.	Total Solids.	Loss on Incin-eration.	Ash.	Nitric Acid.	Saltpetre.	Combined Am-monia.	Urea equivalent.	Ammonia of Animal origin.	"Albumenoid" matters.	Chlorine.	Common Salt.
Water of Passaic Falls.....	4.584	1.501	3.083	0.334	0.024	undet'd	undet'd	0.023	0.294	0.252	0.416
Morris Canal, above Pompton Feeder.....	4.231	0.881	3.350	0.186	0.347	none	none	none	none	0.144	0.238

TABLE VI.

SAMPLES.	Total Solids.	Loss on Incin-eration.	Ash.	Nitric Acid.	Saltpetre equiva-lent.	Combined Am-monia.	Urea equivalent.	Ammonia of Animal origin.	"Albumenoid" matters.	Chlorine.	Common Salt equivalent.
Water of Pompton Plains Feeder.....	3.332	0.764	2.568	0.139	0.260	0.003	0.006	0.029	0.292	0.115	0.190
Calculated Composition of Long Level, below Feeder.....	3.781	0.822	2.959	0.162	0.303	0.001	0.002	0.014	0.146	0.129	0.214
Water of Reach, above Falls.....	4.584	1.501	3.083	0.334	0.024	.....	.....	0.023	0.234	0.252	0.416

4. *The Pompton Plains Feeder.*—As this feeder may be made to bring down the whole of the waters of the Pequannock, the Ramapo, the Wynockie, and the Ringwood, including the water of Greenwood Lake—comprising certainly more than one-third of the whole Passaic water-shed, while coming from a country far less populated and cultivated than the Croton shed—it appeared to me of the utmost importance to examine it well. It will be seen that the results of the analysis fully sustained the expectations formed. Table VI, gives these results by themselves, together with a calculation of the composition of the water of the long level above Patterson, which extends to Bloomfield, on the supposition that the main canal and this feeder bring down equal quantities of water.* I repeat again, for comparison, the composition of the falls :

It would certainly be possible to supply all the low-lying business parts of your two cities (which consume all but a small fraction of the water-supply), through the long level, from this feeder alone, for an almost indefinite time to come, with what is clearly one of the purest waters in the United States. I am here, however, probably intruding somewhat on the engineering questions, which do not lie within my province.

Whether this feeder, or the main canal or any part thereof, be made use of to obtain the proposed water-supply, I have to point out that there are many places along both where the embankments are not continuous, and where small portions of the adjacent land are overflowed, and where shallow pools are accordingly formed, necessarily more or less stagnant, and full of growing and decaying vegetable matter. Such should all be carefully diked off by well puddled embankments.

To be continued.

*It is, nevertheless, proper to add that the amount of the purer water *obtainable* through the feeder is greatly in excess of that which the main canal can bring ; probably, indeed, nearly three times as great, so that a far larger allowance than the above may justly be made, on the side of purity, for the mixture.

APPENDIX.

Franklin Institute Exhibition, 1874.

RULES AND REGULATIONS.

1. The building on Market Street between Thirteenth and Juniper Streets will be open for the reception of all articles and goods intended for exhibition, on Monday, September 14th, and remain open for that purpose until Saturday, October 3d. On Tuesday, October 6th, the Exhibition will be formally opened to the public at 12 o'clock, M., and continue daily open (Sunday excepted) from 10 A. M. to 10 P. M., until Saturday, October 31st.

2. Each Exhibitor will be required to pay Five dollars for each and every entry for competition, at the time the entry is made, and no more than one premium shall be awarded for articles contained in same entry; a *season ticket* shall be furnished to each such exhibitor, *which shall not be transferable*. Not more than one exhibitor's ticket shall be furnished to any one firm or corporation for each entry. Exhibitors may procure tickets for persons necessary for the care and operation of their articles, free of charge, but to be forfeited if used improperly. Articles intended for display only, may, at the discretion of the Committee, be entered without fee; but such entry will confer no privileges upon the exhibitor.

3. All applications for space to be made before October 3d, on printed blank forms, to be furnished by the Committee; and they will be considered and the space allotted in the order of their receipt. Space allotted to applicants and not occupied by October 3d, may be assigned to other exhibitors. Whenever the articles will admit, contributors are requested to exhibit them in glass cases.

4. All articles delivered at the building shall be reported to the Committee, who will direct their location, and assign them the proper space. Any articles shipped to the Exhibition by rail or otherwise, must have freight and charges pre-paid, and invoice and bill of lading mailed to "Committee on Exhibition."

5. Exhibitors will be furnished by the Entry Clerk with duplicate cards, describing each article entered for exhibition; these will be countersigned on the receipt of the articles into the Exhibition. One of these cards shall be conspicuously attached to the article which it describes, and the other must be retained by the exhibitor, and be presented as his order for the delivery of the articles specified, at the close of the Exhibition.

6. The Committee reserves the right to exclude from the premises all articles of a dangerous or offensive character.

7. No articles can be removed from the building, during the time of Exhibition, unless by consent of the Committee.

8. A police force will be in attendance upon the premises during the Exhibition, and watchmen at night; but all articles on exhibition will be at the risk of the owner.

9. There will be two lines of shafting of two and seven-sixteenths inches diameter, one line driven at a speed of 120, and one at 240 revolutions per minute, from which power will be furnished, without charge, for machinery in operation. To secure entire uniformity of motion, all driving pulleys on the line shaft will be supplied by the Institute to the exhibitors, at the lowest trade price. Exhibitors will furnish their own counter-shafting and belting, all plainly marked with their names.

10. The Judges shall be appointed by the Board of Managers, and shall be men

of acknowledged integrity, skill, and experience in the class of articles assigned to them; and no Judge shall serve on any class, in which he may be a competing exhibitor, or otherwise directly interested. The mornings of each day, until fifteen minutes before the time of opening the Exhibition, shall be appropriated to the Judges, who shall be attended only by such persons as they may invite to be present.

11. All articles entered for competition will be carefully examined by the Judges, and Premiums will be awarded on such articles as they shall declare worthy—their decisions being based on intrinsic merit, and not because the article happens to be the best exhibited in any particular class.

12. The Premiums to be awarded shall be of three classes:

1st. The Silver Medal of the Franklin Institute, with a Diploma or Certificate setting forth the peculiar merits of the article exhibited.

2d. The Bronze Medal of the Franklin Institute with a like Diploma.

3d. A Diploma or Certificate of Honorable Mention.

Cases of special merit may be referred by the Judges to the Committee on "Science and the Arts," with a recommendation for the award of the Scott's Legacy Premium, or of the Elliott Cresson Gold Medal.—(See opposite page.)

13. Exhibitors are desired to state in writing to the Committee the peculiar merits claimed for the articles exhibited by them for competition.

14. Signs will not be allowed of greater size than 300 square inches, nor shall such signs be elevated above the goods.

The distribution of circulars and cards or samples about the building will not be permitted; exhibitors can distribute only from their own stand.

Address of the Board of Managers.

To Manufacturers and Mechanics of the United States:

In inviting Contributions to an Exhibition which is intended to celebrate the 50th year of the Franklin Institute, the managers naturally recall the language used by the founders of the Society in their first quarterly report, made to the Institute upon the 15th of April, 1824.

Announcing the intention of holding the first Exhibition of the kind in this country (which was actually held in the month of October, in the year 1824) they say:

"An object of equal, if not greater importance * * * * * is that of public Exhibitions to which all the products of national industry may be sent; the effect and consequence of such Exhibitions will necessarily be to extend the reputation of the Institute, to stimulate the zeal of the members, and to excite a proper degree of emulation and of justifiable rivalry among the numberless manufacturers and mechanics of this city. It is confidently believed that when the products of our industry are collected from the various workshops now dispersed throughout the city and state, and exhibited together, they will form a collection calculated to excite a gratifying sense of pride in the bosom of every well-wisher to the prosperity of our manufactures, and an encouraging hope that, under proper regulations, we may soon compete with foreigners in the manufacture of all useful articles."

These views and hopes have been justified by the success of their pioneer enterprise and of those which followed it, as well as by the general practice now existing, of Annual Exhibitions elsewhere, but more than all, by a comparison of the state of the Arts, fifty years ago, with their condition now.

This comparison may, we trust, be facilitated and illustrated by our intended Exhibition. It cannot be denied that much of the general progress of the Mechanic Arts may fairly be attributed to such expositions, and prosperity in many individual

cases may easily be traced to the public recognition which our exhibitions have invited. On the other hand, the benefits to the community have been equally great, and all the motives which were enumerated by our first Board of Managers are fully in operation to-day.

We hope, therefore, when self-interest and the desire for the public good both incite us to one line of action, that the parties to whom we especially appeal may unite to make our proposed display worthy of the occasion.

In the earlier Exhibitions held by the Franklin Institute, a list of premiums offered was published beforehand, but experience proved that many of the Medals were neither earned or awarded, while the acknowledged excellence or novelty of other articles exhibited, compelled the award of Medals which had not been proposed. The plan was therefore definitely abandoned in 1838, and Medals may now be achieved for any product of Inventive Genius, or by excellence of Execution.

The Scott Legacy Premium, consisting of a Bronze Medal, with the motto "To the most deserving," together with the sum of \$20, is vested in the City of Philadelphia by the provisions of the Will of John Scott of Edinburgh, made in the year 1816, and the city has confided the trust of awarding the premium to the Franklin Institute. It is a premium of peculiar honor, to be distributed among ingenious men and women who make useful inventions.

The Elliott Cresson Gold Medal, an honor which has rarely been awarded, is also entrusted, by the provision of his Will, to the Franklin Institute. It may be awarded for some discovery in the Arts and Sciences, or for the invention or improvement of some useful machine, or for some new process or combination of materials in manufactures, or for ingenuity, skill or perfection in workmanship.

Both of these premiums are awarded by the Board of Managers upon the recommendation of the Committee of Science and the Arts.

In order more readily to find experts qualified to act as judges of each class of articles exhibited for competition, the classification will be made according to the position each article occupies in trade, without regard to any rule based upon the use of the article.

The Rules and Regulations, adopted by the Board of Managers to govern the Exhibition, and all other necessary information, are given herewith.

By order of the Board of Managers,

D. SHEPHERD HOLMAN, *Actuary.*

PHILADELPHIA, *May 13th*, 1874.

INFORMATION.

THE EXHIBITION BUILDING.

The Pennsylvania Railroad Company being about to vacate their Depot on Market Street, between Thirteenth and Juniper Streets, has, with characteristic liberality, placed the building at the disposal of the Committee on Exhibition.

This building contains more than two acres of available space on the ground-floor, besides a large cellar for Storage, and a four story wing at the corner of Thirteenth Street, for Offices, and is therefore by far the largest Exhibition building ever had in Philadelphia.

TRANSPORTATION.

The following Railroad and Steamship Companies have agreed to return free, *over their own lines*, articles which they have carried, intended for the Exhibition, upon which freight has been paid, and which remain unsold.

The paid Freight-bill, countersigned by the proper officer of the Institute, will entitle exhibitors to this privilege.

Pennsylvania Railroad Company.

Philadelphia, Wilmington and Baltimore Railroad Company.

Philadelphia and Reading Railroad Company.

North Pennsylvania " "

Lehigh Valley " "

Phila. and Baltimore Central " "

West Chester and Philad'a " "

West Jersey " "

Camden and Atlantic " "

Clyde's Steam Lines—To Boston, Providence, New York, Richmond, Norfolk, Charleston and Washington.

Philadelphia and Southern Mail Steamship Co.

Baltimore and Philadelphia Steamboat Co.

Swiftsure Transportation Co.—To New York and Hartford.

Boston and Philadelphia Steamship Line.

Philadelphia and Providence Steamship Line.

Lorillards' New York Steamship Line.

The last three Steamship Lines will make a charge for the handling of heavy machinery on the return.

INSURANCE.

Parties desiring to insure against Loss by Fire during this Exhibition, may do so upon a general policy issued to the Franklin Institute, by recording the amount and paying the premium.

SPECIAL TRIALS OF ENGINES AND BOILERS.

In addition to the examination of Stationary Steam Engines and Boilers under the regular rules, covering *all* the qualities comprised in the best machines, it is proposed to make a *special* trial of the evaporative power of Steam Boilers, and of the economy of Boilers with Engines attached, known to the trade as Portable Engines.

These trials to be conducted by practical and scientific experts, with Indicator and Dynamometer and other approved apparatus.

The arrangements for the trials are not yet complete and will mainly depend on the number of the machines that can be brought into competition.

All persons interested in such trials are requested to communicate with the Committee, who will furnish full information as soon as the conditions are arranged.

All communications are to be addressed to the

COMMITTEE ON EXHIBITION,

FRANKLIN INSTITUTE,

Philadelphia.





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